

# ISyDMA

## ISyDMA'6

15 - 17 DECEMBER 2021  
CALAIS - FRANCE

Sixth International  
Symposium on  
Dielectric Materials  
and Applications

<https://isydma6.univ-littoral.fr/>



# **The Sixth edition of International Symposium on Dielectric Materials and Applications**

## **ISyDMA'6**

### **Calais- France**

### **December 15-17, 2021**



**Organized by**

**Dynamics and Structure of Molecular Materials Unit**  
« UNITÉ DE DYNAMIQUE ET DE STRUCTURE DES MATÉRIAUX  
MOLÉCULAIRES: UDSMM »  
**University of Littoral-Côte d'Opale, France**

**IN COOPERATION WITH:**

**Catalysis and Solid-state Chemistry Unit**  
« UNITE DE CATALYSE ET CHIMIE DU SOLIDE : UCCS »  
**University of Artois, Lens, France**

\*\*\*\*\*

**Laboratory of Ceramic Materials and Associated Processes**  
« Laboratoire des Matériaux Céramiques et Procédés Associés : LMCPA »  
**Hauts de France Polytechnic University, Maubeuge, France**

\*\*\*\*\*

**Laboratory of Condensed Matter Physics**  
«Laboratoire de Physique de la Matière Condensée : LPMC »  
**University of Picardy Jules Verne, Amiens, France**

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**Moroccan Association of Advanced Materials**  
**Moroccan Society of Applied Physics**

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**ISyDMA'6 Venue:**

**Amphithéâtre C001**

**Centre Universitaire de la Mi-Voix, 50**

**Rue Ferdinand Buisson 62100 Calais.**

**France**

**For more information about ISyDMA Symposiums, please see :**

**<https://www.isydma.com/>**

**<https://web.facebook.com/ISyDMASymposium/>**

**<https://www.youtube.com/channel/UCQK92VqFHkq9lQMIEoflJuw>**

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## Preface

The ISyDMA conference is an international event focused on recent developments in dielectric materials and their applications. It is aimed at PhD students, post-docs, researchers and engineers from public and private research organizations concerned with innovations in advanced dielectric materials for biomedical, biotechnological and industrial applications.

The conference is aimed at materials specialists, physicists, chemists, biologists and engineers engaged in fundamental and applied research on dielectric materials and their innovative applications.

ISyDMA is open to a large scientific community since it brings together between 150 and 200 researchers and industrialists of 20 to 25 different nationalities. This is the 6th edition, the previous having taken place in Kenitra and Rabat (Morocco) in 2016, in Bucharest (Romania) in 2017, in Beni-Mellal (Morocco) in 2018, in Amman (Jordan) in 2019 and in virtual in 2020 due to the current health context.

ISyDMA'6 is organized as conferences, oral communications and poster sessions. Oral presentations will be grouped by thematic session beginning with invited lectures proposed by the scientific committee or chosen among the submitted papers. Works presented during the meeting will be published in the Conference Proceedings by Springer Nature.

Due to the success of the ISyDMA'3 Pre-Conference: First Moroccan Spring School on Advanced Materials, in Marrakech, Morocco from 15 to 17 April 2018, and the ISyDMA'4 Pre-Conference School in Irbid, Jordan, from 30 April to 1 May, 2019, we are proud to organize the ISyDMA'6 Pre-Conference: International Summer School on Advanced Materials for Energy (ISSAME) on 13 and 14 December 2021 in Saint-Omer, France. The scope of this Summer School is to familiarize students with the state of the art in advanced materials for energy. The target audience for the Pre-Conference School is graduate students and junior researchers (PhD students, postdocs).

In addition to the scientific program of these two events, the attendees have a chance to discover the beauty of Calais and the Opal Coast with their several historical monuments classified as World Heritage by UNESCO and the numerous port cities full of history and various resorts that offer a wide range of activities. The social program is extraordinary, reflecting the French sense of hospitality and generosity combined with fun, for the participants and their companions.

For the ISyDMA'6 committees

A.Pr. TACHAFINE Amina and Pr. Didier FASQUELLE  
Littoral-Côte d'Opale University, Calais, France  
Chairs of ISyDMA'6



Sponsors

			
			
			
			
 <p>Moroccan Association for Advanced Materials</p>	 <p>Materials Moroccan Society of Applied Physics</p>		 <p>Réalisation SCOSi - Pôle IPM Informatique Pédagogique Multimédia</p>

## **Scope and Topics**

Presentations cover a broad range of topics from basic to applied sciences related to major issues such as energy, environment, biotechnology, electronics and optoelectronics. The contributions organized in four sections will focus on the following topics:

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### **Section 1 : Dielectric materials for electronics and photonics**

- Dielectric, piezoelectric, pyroelectric, ferroelectric and multiferroic materials
- Ceramics, thin films, polymers, glasses, composites and nanostructures
- Impedance spectroscopy to electrochemical and dielectric phenomena
- Dielectric properties, polarization phenomena and applications
- Surface and interfacial phenomena
- Physics of space charge in non-conductive materials
- Space charge and its effects in dielectrics
- Advanced characterization
- Modeling and theory
- Applications of multiferroics

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### **Section 2 : Applications of insulators**

- High voltage insulation design using computer; based analysis
- Partial discharges in insulation: detection methods and impact on ageing
- Monitoring and diagnostic methods for electrical insulation degradation
- Electrical insulation in high voltage power equipment and cables
- Ageing, partial discharges and life expectancy of HV insulation
- Electrical conduction and breakdown in dielectrics liquids
- Gaseous electrical breakdown and discharges

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### **Section 3 : Dielectric devices for biotechnological and industrial applications**

- Biodielectrics for environmental applications and bioengineering systems
- Biomedical engineering
- Tunable microwave devices
- Electrical energy storage, supercapacitors, electrostatic capacitors, electrolytors, batteries
- Electrical energy generation, Solid Oxide Fuel Cell
- Nanodielectrics for Industrial applications
- Dielectrics for superconducting applications
- Measurement techniques
- Electrocaloric materials, Thermoelectrics, Photovoltaics

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### **Section 4 : Emerging materials and devices**

- Metamaterials
- Nanocomposite dielectric polymers
- New diagnostic applications for dielectrics
- New and functional dielectrics for electrical systems
- Topological insulators
- Composite materials
- Other related dielectric phenomena and techniques.

## Committees

### ISyDMA'6 Chairs

- TACHAFINE Amina: Littoral-Côte d'Opale University, Calais, France
- FASQUELLE Didier: Littoral-Côte d'Opale University, Calais, France
- DESFEUX Rachel : University of Artois, Lens, France
- COURTOIS Christian: Hauts de France Polytechnic University, Maubeuge, France
- GAGOU Yaovi: University of Picardy Jules Verne, Amiens, France
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- OUERAGLI Amane: Cadi Ayyad University, Marrakech, Morocco
- MABROUKI Mustapha: Soltan Molay Sliman Univ. Beni-Mellal, Morocco
- AIT ALI Mustapha: Cadi Ayyad University, Marrakech, Morocco
- LEBLANC Roger M.: University of Miami, Florida, USA
- VASEASHTA Ashok: International Clean Water Institute, Manassas, Virginia, USA

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- BERTRAND Xavier: President of the Regional Council of "Hauts de France", France.
- BOUCHART Natacha: Mayor of the City of Calais and President of the "Agglomération Grand Calais Terres et Mers", France.
- SADOK Hassan: President of the University of Littoral-Côte d'Opale, France
- ABI AAD Edmond: Vice-President Research of the University of Littoral-Côte d'Opale, France.
- DAOUDI Abdelylah: Director of the Dynamics and Structure Molecular Materials Unit, University of Littoral-Côte d'Opale, France.
- CARRU Jean-Claude: Professor Emeritus, Dynamics and Structure of Molecular Materials Unit, University of Littoral-Côte d'Opale, France.
- TRYBULA Zbigniew: Professor, Director of the Institute of Molecular Physics, the Polish academy of sciences, Poznani, Poland.
- OGWU Abraham Atta: Professor, Vice Rector for internationalisation, East Kazakhstan State Technical University, Ust-Kamenogorsk, Kazakhstan.
- MOUSA Marwan Suleiman: Professor, Vice President of Mu'tah University (for Research, Planning and Int. Relations), Al-Karak, Jordan. President of the Jordanian Club of Humboldt Fellows (JCHF), President of the Jordanian Physics Society (JPS).

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## ISyDMA'6 Planning



<b>ISyDMA</b>							
<b>Wednesday December 15 2021</b>	<b>Morning</b>	<b>8H-9H</b> Registration	<b>9H -9H45</b> Opening Ceremony	<b>9H45 -10H15</b> Welcome reception	<b>10H15-12H15</b> Conferences: 1, 2, 3, 4	<b>12H15-13H30</b> Oral Presentations Onsite Sessions A and B	<b>13H30-14H45</b> Photo of ISyDMA'6 Group & Lunch
	<b>Afternoon</b>	<b>14H45-16H45</b> Conferences: 5, 6, 7		<b>16H45-17H</b> Coffee-break		<b>17H-19H</b> Oral Presentations Onsite Sessions C and D	
<b>Thursday December 16 2021</b>	<b>Morning</b>	<b>8H30-10H30</b> Registration & Conferences: 8, 9, 10, 11	<b>10H30-11H</b> Coffee-break & Poster session (I)	<b>11H00-13H30</b> Oral Presentations Online		<b>13H30-14H30</b> Lunch	
	<b>Afternoon</b>	<b>14H45-19H</b> Visit: Grand site des Deux-Caps on the Opal coast and Nausicaa national sea center				<b>19H30</b> Gala Dinner	
<b>Friday December 17 2021</b>	<b>Morning</b>	<b>8H30-10H30</b> Registration & Conferences: 12, 13, 14	<b>10H30-11H00</b> Coffee-break & Poster session (II)	<b>11H00-13H40</b> Oral and Poster Presentations Online		<b>13H40-14H45</b> Lunch	
	<b>Afternoon</b>	<b>14H45-16H45</b> Conferences: 15, 16, 17, 18	<b>16H45-17H15</b> Coffee-break	<b>17H15-18H45</b> Awards & Closing			

## ISyDMA'6 Program

Wednesday 15 December, 2021		
08:00-9:00	<b>Registration</b>	
09:00-09:45	<b>Opening ceremony</b>	
09:45-10:15	<b>Welcome reception</b>	
10:15-12:15	<b>Conferences:</b> 1, 2, 3, 4 <b>Amphitheater C001</b> <b><u>Chairs : Prof. A. Vaseashta and Prof. L.C. Costa</u></b>	
10:15-10:45	<b><u>Conference 1 (Conf 01)</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Didier FASQUELLE</u></b> <i>Dynamics and Structure of Molecular Materials Unit (UDSMM)</i> <i>Littoral-Côte d'Opale University, Calais</i> <i>France</i> <b>Study and Optimization of Functional Oxide Properties: From Prediction to dedicated Characterizations.</b>	
10:45-11:15	<b><u>Conference 2 (Conf 02):</u></b> <b><u>Invited Speaker:</u></b> <b><u>Prof. Yasuo CHO</u></b> <i>Research Institute of Electrical Communication, Tohoku University, 2-1-1 Katahira,</i> <i>Aoba-ku, Sendai</i> <i>Japan</i> <b>Nanoscale Domain Dynamics Characterization Using Local C-V Mapping</b>	
11:15-11:45	<b><u>Conference 3 (Conf 03):</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Friedrich KREMER</u></b> <i>Institute of Experimental Physics I</i> <i>University of Leipzig, Leipzig</i> <i>Germany</i> <b>Molecular dynamics in 1- and 2-dimensional nanometric confinement as studied by Broadband Dielectric Spectroscopy</b>	
11:45-12:15	<b><u>Conference 4 (Conf 04):</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Juras BANYS</u></b> <i>Faculty of Physics, Vilnius University, Sauletekio 3, LT-10257 Vilnius</i> <i>Lithuania</i> <b>Peculiarities of dipolar ordering in mixed cation halide perovskites</b>	
12:15-13:15	<b>Oral sessions</b> <b>Sessions A and B</b> <b>Onsite</b>	
	<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> <b><u>Session A</u></b>  <b>Amphitheater C001</b>  <b><u>Chairs : Prof. R. BENZERGA</u></b>  <b><u>Prof. Y. LORGOUILLOUX</u></b> </td> <td style="width: 50%; border: none; vertical-align: top;"> <b><u>Session B</u></b>  <b>Room B014</b>  <b><u>Chairs : Prof. J. Mustapha</u></b>  <b><u>Prof. G. Leroy</u></b> </td> </tr> </table>	<b><u>Session A</u></b> <b>Amphitheater C001</b> <b><u>Chairs : Prof. R. BENZERGA</u></b> <b><u>Prof. Y. LORGOUILLOUX</u></b>
<b><u>Session A</u></b> <b>Amphitheater C001</b> <b><u>Chairs : Prof. R. BENZERGA</u></b> <b><u>Prof. Y. LORGOUILLOUX</u></b>	<b><u>Session B</u></b> <b>Room B014</b> <b><u>Chairs : Prof. J. Mustapha</u></b> <b><u>Prof. G. Leroy</u></b>	
	<b><u>OP-A1</u></b> <b><u>Pierre VOISIN</u></b> <b><u>HTDS</u></b>	

	<b>12:15-12:45</b>	
12:15-12:30		<b><u>OP-B01</u></b> <b><u>Shivani SHISODIA</u></b> Effect of Nanostructuring on Thermoelectric Properties of Polymer Nanocomposites
12:30-12:45		<b><u>OP-B02</u></b> <b><u>Amina DIEMMAH</u></b> Processing high permittivity rutile TiO <sub>2</sub> for all-dielectric metamaterials applications at terahertz frequencies
12:45-13:00	<b><u>OP-A02</u></b> <b><u>Anthony FERRI</u></b> Investigating the nanoscale physical properties of electroactive PVDF-based nanocomposites	<b><u>OP-B03</u></b> <b><u>Asmita SHAH</u></b> Coping with the poor conductivity of organic semiconductor liquid crystals via carbon-dots dispersion
13:00-13:15	<b><u>OP-A03</u></b> <b><u>Lavinia- P. CURECHERIU</u></b> Role of composition on the electrocaloric properties of BaM <sub>x</sub> Ti <sub>1-x</sub> O <sub>3</sub> ceramics	<b><u>OP-B04</u></b> <b><u>Jamal BELHADI</u></b> Control, quantification, and mapping of elastic strains in epitaxial ferroelectric BaZrO <sub>3</sub> /BaTiO <sub>3</sub> superlattices
13:15-14:45	<b>Photo of ISyDMA'6 Group &amp; Lunch</b>	
14:45-16:45	Conferences: 5, 6 and 7 <b><u>Amphitheater C001</u></b> <b><u>Chairs : Prof. R. DESFEUX + Prof. M. STRICCOLI</u></b>	
14:45-15:15	<b><u>Conference 5 (Conf 05)</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Ashok VASEASHTA</u></b> <i>NJCU-State University of New Jersey, NJ USA</i> Electrospun Nanofibers of High Performance Electret Polymers for Tactile Sensing and Wearable Electronics	
15:15-15:45	<b><u>Conference 6 (Conf 06)</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Dumitru TSIULYANU</u></b> <i>CIMAN Research Centre of Department of Physics, Technical University of Moldova, Chisinau Moldova</i> Physical – chemical properties of sulfur enriched As-S-Ge glasses related to middle-range order structure	
15:45-16:15	<b><u>Conference 7 (Conf 07)</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Mohamed-Ali AL-AKHRAS</u></b> <i>Department of Physics Jordan University of Science &amp; Technology (JUST), Irbid Jordan</i> Novel therapeutic approach of using herbal nanopowder in Photodynamic therapy (PDT)	
16:15-16:45	<b>Coffee-break</b>	
16:45-18:45	<b>Oral sessions</b> <b>Sessions C and D</b>	



<b>Onsite</b>	
17:00-19:00	<b>Session C</b> <b>Amphitheater C001</b> <b>Chairs : Prof. <u>Didier FASQUELLE</u></b> <b>Prof. <u>Anthony FERRI</u></b>
17:00-17:15	<b>OP-C01</b> <b>Prof. <u>Yasuo CHO</u></b> Recording Medium Design Aiming at Realizing Ferroelectric Probe Data Storage
17:15-17:30	<b>OP-C02</b> <b>Marie-Hélène CHAMBRIER</b> Ferroelectric state in $\alpha$ -Ln <sub>2</sub> WO <sub>6</sub> polymorphs stabilized in thin film form
17:30-17:45	<b>OP-C03</b> <b>Leontin PADURARIU</b> Modeling of the dielectric properties in ferroelectric-based composites by Finite Element Method
17:45-18:00	<b>OP-C04</b> <b>Hassan YASSINE</b> Study of the aging of Lithium-ion coin cells with impedance and noise measurements
18:00-18:15	<b>OP-C05</b> <b>Mohamed RGUITI</b> Optimization of (Ba,Ca)(Zr,Ti)O <sub>3</sub> lead-free piezoelectric ceramics properties by variation of the composition
18:15-18:30	<b>OP-C06</b> <b>Parthiban PALANI</b> Structural, morphological and frequency dependent dielectric properties of Sr <sub>1-x</sub> Ca <sub>x</sub> TiO <sub>3</sub> (0.30 ≤ x ≤ 0.40) ceramics
18:30-18:45	<b>OP-C07</b> <b>Hanadi BREISS</b> Ultra-porous composites based on epoxy foam loaded with carbon fibers for microwave absorption
<b>Thursday December 16, 2021</b>	
08:30-10:30	<b>Registration &amp; Conferences: 8, 9, 10 and 11</b> <b>Amphitheater C001</b> <b>Chairs : Prof. <u>D. FASQUELLE</u> &amp; Prof. <u>D. TSIULYANU</u></b>
08:30-09:00	<b>Conference 8 (Conf 08)</b> <b>Invited Speaker :</b> <b>Prof. <u>Rachel DESFEUX</u></b> <i>Unité de Catalyse et Chimie du Solide (UCCS)</i>

	<p><i>University of Artois , Lens</i>  <i>France</i>  <b>Nanoscale Ferroelectricity in Innovative Lead-Free Oxide Thin Films</b></p>	
09:00-09:30	<p><b><u>Conference 9 (Conf 9)</u></b>  <b><u>Invited Speaker :</u></b>  <b><u>Prof. Luis Cadillon COSTA</u></b>  <i>IBN and Physics Department</i>  <i>University of Aveiro, Aveiro</i>  <i>Portugal</i>  <b>Microwave radiation: applications in metrology and materials synthesis</b></p>	
09:30-10:00	<p><b><u>Conference 10 (Conf 10)</u></b>  <b><u>Invited Speaker :</u></b>  <b><u>Prof. Marinella STRICCOLI</u></b>  <i>National Research Council of Italy</i>  <i>Institute for Physical and Chemical Processes - Bari Division, Bari</i>  <i>Italy</i>  <b>Nanomaterials and their assemblies:</b>  <b>advanced functionalities towards technological applications</b></p>	
10:00-10:30	<p><b><u>Conference 11 (Conf 11)</u></b>  <b><u>Invited Speaker :</u></b>  <b><u>Prof. Mustapha AIT ALI</u></b>  <i>Molecular Chemistry Laboratory Coordination Chemistry and Catalysis Unit</i>  <i>Faculty of Sciences-Semlalia, Cadi Ayyad University, Marrakech</i>  <i>Morocco</i>  <b>Chemical synthesis of 2D-nanomaterials: Functionalized silicene and phosphorene</b></p>	
10:30-11:00	<p style="text-align: center;"><b>Coffee-break</b>  <b>&amp;</b>  <b>Poster session (I) : Onsite</b></p>	
	<p style="text-align: center;"><b>Oral Presentations : Online</b></p>	
11:00-13:30	<p><b><u>Session VA</u></b>  <b><u>Amphitheater C001</u></b>  <b>Chair of session :</b>  <b><u>Prof. Luis Cadillon COSTA</u></b>  <b><u>Prof. Marie-Hélène</u></b>  <b><u>CHAMBRIER</u></b></p>	<p><b><u>Session: VB</u></b>  <b><u>Amphitheater Parreau</u></b>  <b>Chair of session :</b>  <b><u>Prof. Tamara PETKOVA</u></b>  <b><u>Prof. Dharmendra P. SINGH</u></b></p>
11:00-11:15	<p><b><u>OP-VA01</u></b>  <b><u>Giacomo BUCELLA</u></b>          Electronic structure of defected polyethylene for Schottky emission</p>	<p><b><u>OP-VB01</u></b>  <b><u>Nidal KHEMMOU</u></b>          Effect of an additive organic A1 in improving the quality of nickel electroplating on brass</p>
11:15-11:30	<p><b><u>OP-VA02</u></b>  <b><u>Mohamed EL HASNAOUI</u></b>          Lead titanate ferroelectric thin films prepared by polymeric precursor method</p>	<p><b><u>OP-VB02</u></b>  <b><u>Khaoula Mzioud</u></b>          Synergistic formulation from Allium Sativum essential oil and diethyl thiourea for corrosion inhibition of carbon steel in 0.5 M H2SO4 medium.</p>
11:30-11:45	<p><b><u>OP-VA03</u></b>  <b><u>Yassine NIOUA</u></b>          Electric modulus spectroscopic studies of the dielectric properties in reduced Graphene Oxide loaded epoxy polymer composites</p>	<p><b><u>OP-VB03</u></b>  <b><u>Nouhaila FERRAA</u></b>          The anti-corrosive property of apatite tricalcium phosphate on carbon steel in two acid media HCl 1M and H2SO4 0.5 M</p>
11:45-12:00	<p><b><u>OP-VA04</u></b>  <b><u>Yassine EL HASNAOUI</u></b></p>	<p><b><u>OP-VB04</u></b>  <b><u>Bhavna PAL</u></b></p>

	Dielectric Resonator with a Novel Antenna geometry fed by a microstrip line for 5G applications.	Molecular simulations of dielectric and spectroscopic properties of 4-cyano-4'-pentylbiphenyl liquid crystal and their comparison with experimental findings
12:00-12:15	<b><u>OP-VA05</u></b> <b><u>Zineb SAMIR</u></b> Dielectric spectroscopy of melt-extruded polypropylene carbon nanofiber composites	<b><u>OP-VB05</u></b> <b><u>Vasily TROTSENKO</u></b> Synthesis, dielectric, Raman and IR spectroscopic studies of BiScO <sub>3</sub> phase samples with a perovskite-type structure
12:15-12:30	<b><u>OP-VA06</u></b> <b><u>Marwa ZAHID</u></b> Low temperature synthesis and characterization of barium stannate titanate powders	<b><u>OP-VB06</u></b> <b><u>Vasily TROTSENKO</u></b> Local symmetry breaking and formation of low-symmetry phase in Sr <sub>0.97</sub> Ba <sub>0.03</sub> TiO <sub>3</sub> ceramic and thin film studied by vibrational spectroscopy
12:30-12:45	<b><u>OP-VA07</u></b> <b><u>Abdallah NAYAD</u></b> New two-dimensional functionalized silicon dispersible nanosheets prepared by direct exfoliation of calcium disilicide	
12:45-13:00	<b><u>OP-VA08</u></b> <b><u>Salma Kaotar HNAWI</u></b> Investigation of Aloe Vera Latex used as Natural Dye in TiO <sub>2</sub> based Heterojunction and Liquid-Electrolyte Dye Sensitized Solar Cells	
13:00-13:15	<b><u>OP-VA09</u></b> <b><u>Faissal EL MANJLI</u></b> From red phosphorus to 2D phosphorene: synthesis and characterization	
13:15-13:30	<b><u>OP-VA10</u></b> <b><u>Youness HADOUCH</u></b> Giant electrocaloric effect and high energy storage efficiency in lead free BCTSn ceramic elaborated by sol gel method	
<b>Friday December 17, 2021</b>		
8:30-10:00	<b>Conferences:</b> <b>12, 13 and 14</b> <b><u>Amphitheater C001</u></b> <b><u>Chairs of session: Prof. R. BENZERGA and Prof. Y. CHO</u></b>	
8:30-9:00	<b><u>Conference 12 (Conf 12)</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Nathalie LEMEE</u></b> <i>Laboratoire de physique de la Matière Condensée, UR 2081, Université de Picardie Jules Verne, 33 rue Saint-Leu, 80039 Amiens France</i> <b>Nanodomains in ferroelectric / dielectric superlattices : a key role in the structural and functional properties</b>	
9:00-9:30	<b><u>Conference 13 (Conf 13)</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Cyril POPOV</u></b> <i>Institute of Nanostructure Technologies and Analytics (INA)  Center for Interdisciplinary Nanostructure Science and Technology (CINSA-T)</i>	

	University of Kassel, Kassel Germany Fabrication and Characterization of Single-Crystal Diamond Membranes for Photonic Devices		
9:30-10:00	<b>Conference 14 (Conf 14)</b> <b>Invited Speaker :</b> <b><u>Prof. Vid BOBNAR</u></b> <i>Condensed Matter Physics Dept., Jožef Stefan Institute, Jamova 39, 1000 Ljubljana                  Slovenia</i> Nanostructured multiferroic Pb(Zr,Ti)O <sub>3</sub> -NiFe <sub>2</sub> O <sub>4</sub> thin-film composites		
10:00-11:00	<b>Coffee-break</b> <b>&amp;</b> <b>Poster session (II) : Onsite</b>		
11:00 - 13:00	<b><u>Session OP-VC</u></b> <b>Oral Presentations Online</b> <b><u>Amphitheater C001</u></b> <b><u>Chairs : Prof. Y.LORGOUILLOUX</u></b> <b><u>Prof. N. LEMEE</u></b>	11:00 - 12:00	<b><u>Session PP-V</u></b> <b>Poster Presentations: Online</b> <b><u>Amphitheater Parreau</u></b> <b><u>Chairs : Prof. J.C. CARRU</u></b> <b><u>Prof. D. FASQUELLE</u></b>
11:00 - 11:15	<b><u>OP-VC01</u></b> <b><u>Ilham BOUKNAITIR</u></b> AC conductivity and dielectric response of carbon dots/PMMA nanocomposite materials	11:00 - 11:05	<b><u>PP-V01</u></b> <b><u>Afaak LAKOUADER</u></b> Synthesis, structure, dielectric, and energy storage properties of Ba <sub>0.85</sub> Ca <sub>0.15</sub> Zr <sub>0.1</sub> Ti <sub>0.9</sub> O <sub>3</sub> ceramics under large electric field
11:15 - 11:30	<b><u>OP-VC02</u></b> <b><u>Zakia ARIBOU</u></b> Effects of Additive in an Electrodeposition Bath on the Surface Morphologic Evolution of Electrodeposited Copper	11:05 - 11:10	<b><u>PP-V02</u></b> <b><u>Safia DRISSI</u></b> Preparation and characterization of Cu <sub>2</sub> Fe <sub>1-x</sub> CoxSn <sub>4</sub> thin films via sol- gel method
11:30 - 11:45	<b><u>OP-VC03</u></b> <b><u>Zineb GARGAR</u></b> Electrical, and dielectric properties of Yttrium-doped BaTiO <sub>3</sub> ceramics	11:10 - 11:15	<b><u>PP-V03</u></b> <b><u>Afaak LAKOUADER</u></b> A comparative study of structural, electrical, and energy storage properties in lead-free BCZT ceramics: Influence of the reduced thickness of ceramics.
11:45 - 12:00	<b><u>OP-VC04</u></b> <b><u>Soukaina SAISSI</u></b> The improvement of mechanical properties of lead acid battery grids	11:15 - 11:20	<b><u>PP-V04</u></b> <b><u>Abdeslem BELDILALI</u></b> Influence of the Metal/Dielectric Contact on the Reliability of the Insulation Electrical Systems
12:00 - 12:15	<b><u>OP-VC05</u></b> <b><u>Messaoud HAMOUDA</u></b> The mechanism study of the breakdown process of air near the flashover discharge	11:20 - 11:25	<b><u>PP-V05</u></b> <b><u>Najoia ARIBOU</u></b> Investigation of dielectric properties of water dispersion of reduced graphene oxide/water nanofluid composite
12:15 - 12:30	<b><u>OP-VC06</u></b> <b><u>Artyom PLYUSHCH</u></b> Composite multiferroics with phosphate ceramic as a matrix	11:25 - 11:30	<b><u>PP-V06</u></b> <b><u>Victor BOEV</u></b> Ureasilicate organic-inorganic hybrids doped with heteropoly acid
12:30 -	<b><u>OP-VC07</u></b>	11:30 -	<b><u>PP-V07</u></b>

12:45	<b><u>Sarunas SVIRSKAS</u></b> Dielectric relaxation in Ba(Ti <sub>1-x</sub> Sn <sub>x</sub> )O <sub>3</sub> solid solutions	11:35	<b><u>Martynas KINKA</u></b> Investigation of linker rotation dynamics in ZIF-8, ZIF-67 and ZIF-90 metal-organic frameworks using broadband dielectric spectroscopy
12:45 - 13:00	<b><u>OP-VC08</u></b> <b><u>Ekaterina POLITOVA</u></b> Dielectric properties of new lead-free oxide materials ceramics on the base of KNN and NBT perovskites	11:35 - 11:40	<b><u>PP-V08</u></b> <b><u>Vania ILCHEVA</u></b> Encapsulation of TiO <sub>2</sub> nanosized particles in ureasil organic-inorganic hybrid obtained by sol-gel method
13:00 - 13:15	<b><u>OP-VC09</u></b> <b><u>Najoia ARIBOU</u></b> Thermal and Spectral Dielectric Properties of Polypyrrole/Polymethylmethacrylate Composites	11:40 - 11:45	<b><u>PP-V09</u></b> <b><u>Said ELMASSI</u></b> Optimisation of the density of copper oxide nanowires synthesized by the electrochemical technique followed by annealing
		11:45 - 11:50	<b><u>PP-V10</u></b> <b><u>Mohammed BOUSSETA</u></b> Effect of RF power and annealing on the structural, optical and morphological properties of RF-sputtered V <sub>2</sub> O <sub>5</sub> thin films
		11:50 - 11:55	<b><u>PP-V11</u></b> <b><u>Ali BOUGHAROUAT</u></b> A comparison of polypropylene-surface treatment by AC corona and dielectric-barrier corona discharges in the air
		11:55 - 12:00	<b><u>PP-V12</u></b> <b><u>Housseem Eddine BOUSBA</u></b> Effect of different plasma working gas mixtures on the decontamination of fungus polluted water
		12:05 - 12:10	<b><u>PP-V13</u></b> <b><u>Saadia AFEISSA</u></b> A possible crosslinking behavior of crosslinkable Silane-XLPE HV insulation under cyclic accelerated weathering aging
		12:10 - 12:15	<b><u>PP-V14</u></b> <b><u>Hassan CHAIB</u></b> Electrical and optical properties of room temperature potassium niobate single
		12:15 - 12:20	<b><u>PP-V15</u></b> <b><u>Abdellah HBAB</u></b> DFT investigation of structural, electronic and optical properties of lithium niobate in its ferroelectric phase

14:45 - 16:15	<b>Conferences:</b> <b>15, 16, 17 and 18</b> <b><u>Amphitheater C001</u></b> <b><u>Chairs of session: Prof. M. H CHAMBRIER &amp; Prof. D. P. SINGH</u></b>
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14:45 - 15:15	<b><u>Conference 15 (Conf 15)</u></b> <b><u>Invited Speaker :</u></b> <b><u>Prof. Yiqun. ZHOU</u></b> <i>Department of Chemistry, University of Miami, Coral Gables, FL 33146</i> <i>USA</i> <b>Physicochemical Characterization of a Novel Carbon Nanomaterial: Carbon Dots</b>
15:15 - 15:45	<b><u>Conference 16 (Conf 16)</u></b> <b><u>Prof. Tamara PETKOVA</u></b> <i>Institute of Electrochemistry and Energy Systems, Bulgarian Academy of Sciences, Sofia</i> <i>Bulgaria</i> <b>Influence of synthesis route on morphology and conduction behavior of proton conducting electrolytes with perovskite-structure</b>
15:45 - 16:15	<b><u>Conference 17 (Conf 17)</u></b> <b><u>Prof. Ratiba BENZERGA</u></b> <i>Univ Rennes, CNRS, IETR-UMR 6164, F-35000, Rennes</i> <i>France</i> <b>Cork-based composites for microwave absorbing materials</b>
16:15 - 16:45	<b><u>Conference 18 (Conf 18)</u></b> <b><u>Prof. Asma TRIKI</u></b> <i>Laboratory of Composites Materials, Ceramics and Polymers, University of Sfax</i> <i>Tunisia</i> <b>Adhesion analysis of non-woven hybrid cotton fibers in unsaturated polyester by dielectric spectroscopy</b>
16:45 - 17:15	<b>Coffee-break</b>
17:15 - 18:45	<b>Awards &amp; Closing</b>

Ref.	<b>List of Posters session (I) (Onsite)</b>
<b>PS-01</b>	<b><u>Ratiba BENZERGA</u></b> <b>Ultra-Wideband Planar Multilayer Absorber Based on Long Carbon Fibers Loaded Epoxy Foam Composites</b>
<b>PS-02</b>	<b><u>Ratiba BENZERGA</u></b> <b>Hybrid material to broaden the absorption bandwidth of a metamaterial absorber</b>
<b>PS-03</b>	<b><u>Petar PERVAN</u></b> <b>Comparison of poled glass SIMS data with concentration profile simulations and corresponding refractive index</b>
<b>PS-04</b>	<b><u>Frédéric DUBOIS</u></b> <b>Characterization of Liquid Crystals recovered from End-of-Life Liquid Crystal Displays using Dielectric Spectroscopy</b>
<b>PS-05</b>	<b><u>Frédéric DUBOIS</u></b> <b>Dielectric properties of dispersions of nanoparticles in polymer/liquid crystal films</b>
<b>PS-06</b>	<b><u>Ratiba BENZERGA</u></b> <b>High power microwave absorbers based on glass foam composites</b>
<b>PS-07</b>	<b><u>Hanadi BREISS</u></b> <b>Effect of fiber length on microwave absorption frequency band of composites based on carbon fiber loaded epoxy foam</b>
<b>PS-08</b>	<b><u>Antonio DA COSTA</u></b> <b>Fabrication of ferroelectric tunnel nano-junctions in P(VDF-TrFE) thin films with a fine control by Conductive-AFM</b>

<b>PS-09</b>	<b><u>Antonio DA COSTA</u></b> 2D material dependence on the crystallization and ferroelectric properties in organic P(VDF-co-TrFE) thin films
<b>PS-10</b>	<b><u>Vesna BLAŽEK BREGOVIĆ</u></b> Electric field assisted dissolution of Al and Cu metal thin films
<b>PS-11</b>	<b><u>Mégane LHEUREUX</u></b> Microstructure and nanoscale piezoelectric properties in Ba <sub>0.85</sub> Ca <sub>0.15</sub> Ti <sub>0.9</sub> Zr <sub>0.1</sub> O <sub>3</sub> (BCTZ) thin films grown by pulsed laser deposition
<b>PS-12</b>	<b><u>Cristina Elena CIOMAGA</u></b> Study of the structural, dielectric and ferroelectric properties in Ba <sub>0.85</sub> Ca <sub>0.15</sub> Ti <sub>0.9</sub> Zr <sub>0.1</sub> O <sub>3</sub> ceramics
<b>PS-13</b>	<b><u>Cristina Elena CIOMAGA</u></b> The role of microstructure on dielectric properties of polymer-based composites: Experiment and modelling
<b>PS-14</b>	<b><u>Ratiba BENZERGA</u></b> "Synthesis and dielectric characterization of perovskite (Sr <sub>2</sub> Ta <sub>2</sub> O <sub>7</sub> ) <sub>100-x</sub> (La <sub>2</sub> Ti <sub>2</sub> O <sub>7</sub> ) <sub>x</sub> ceramics: application to dielectric resonator antennas"

## **Abstracts**

## **Plenary Talks**

## **Conf 01**

### **Study and optimization of functional oxide properties: from prediction to dedicated characterizations**

**D. FASQUELLE<sup>a</sup>, P. PALANI<sup>a</sup>, S. CHAHIB<sup>a</sup>, A. TACHAFINE<sup>a</sup>, G. LEROY<sup>a</sup>**

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In Europe, the RoHS directive (Restriction of Hazardous Substances) was the first in its gender. Indeed it was the first political decision to prohibit some hazardous substances. Among these substances, lead is one of the majors because this inorganic material is responsible of many deceases of the digestive system and brain, and of some kinds of tumours. Accordingly, it is now necessary to implement materials without these prohibited or hazardous substances. Lead-free functional oxides can be dedicated to numerous applications. Every kind of oxide can be chosen and optimized for a specific industrial application. Among these lead-free oxides, doped barium titanates show an evident interest due to their pseudo-cubic perovskite structure. Indeed the microstructural and electrical properties of these functional oxides can be fine-tuned by an appropriate exchange in the A and/or B sites of the unit cell. Here a part of some studies will be presented.

Before the presentation of experimental results, prediction must be introduced. What is a prediction? A prediction is a statement about what you think will happen in the future. Effectively scientists are a part of the emitters of prediction because our common life is surrounded by predictions for weather, sales, climate, market trends and so on...

The first part of the presentation will be related to SCT ceramics and films dedicated to electrical energy storage (EES). Actually the goal is to use SCT for the manufacturing of electrostatic capacitors. Here the prediction is centred on the fact that SCT could show an anti-ferroelectric behaviour for some particular compositions. To our knowledge, this is still a prediction as it has not been demonstrated at the macroscopic level by an exhibition of an anti-ferroelectric polarization cycle. Additionally SCT could be also used for the manufacturing of high-Q capacitors for electronic devices. But here the road has already been paved [1-2].

The second part of the talk will be related to simulation tools. In this way, simulations can be very powerful for studying the effect of a chosen dopant on the oxide properties. Here another prediction was done: we can dope an oxide, a potential candidate for solar cell application, for decreasing its energy gap. Indeed a lower  $E_g$  is more suitable for photovoltaic conversion. Cobalt (Co) was used as a dopant to investigate its influence on the structural, electronic and optical properties of  $\text{BaSnO}_3$  oxide by using density functional theory (DFT) within WIEN2K-code based on the generalized gradient approximation (GGA) and the modified Becke-Johnson exchange potential (mBJ). Calculations were performed for  $\text{BaSn}_{1-x}\text{Co}_x\text{O}_3$  ceramics,  $x = 0, 12.5, 25, 37.5$  and  $50\%$  [3]. This last part effectively shows how theoretical studies and simulations can be used to predict properties and for tuning them. And of course, these predictions and calculations have a great interest because they are done before doing any experimental development. This is thus very powerful for guiding the experimental works.

#### **References**

- [1] Thèse Hichan Ait Laasri soutenue à l'ULCO le 29/06/2018.
- [2] H. Ait Laasri, D. Fasquelle, A. Tachafine, N. Tentillier, L. C. Costa, M. Elaattmani, A. Outzourhit and J.-C. Carru. *Functional Materials Letters* Vol. 11, No. 2 (2018) 1850005.
- [3] S. Chahib, D. Fasquelle and G. Leroy. *Materials Science in Semiconductor Processing*. 2021. In processing.



**Conf 02**

**Nanoscale Domain Dynamics Characterization Using Local C-V Mapping**

**HIRANAGA Y.<sup>1</sup>, MIMURA T.<sup>2</sup>, SHIMIZU T.<sup>2</sup>, FUNAKUBO H.<sup>2</sup>, CHO Y.<sup>1</sup>**

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Nanoscale characterization of polarization switching behavior is important in the future development of piezoelectric and ferroelectric devices. Recently, we have developed a novel probe microscopy technique for local C-V mapping based on scanning nonlinear dielectric microscopy (SNDM). This method enables detailed analysis of dynamic polarization switching behavior beyond the conventional static domain observation.

An SNDM system has an LC oscillator probe, which enables local capacitance deviation to be detected with high sensitivity. In a conventional SNDM observation, an AC bias voltage below a domain switching voltage is applied to a sample, and a nonlinear response is detected to visualize the static domain structure. On the other hand, in the novel method, the response is measured with a large-amplitude AC bias above the polarization switching voltage. For ferroelectric films, C-V curves observed in this way draw a butterfly curve, as with macroscopic measurements. By analyzing such local C-V butterfly curves, various parameters related to polarization switching can be obtained.

In this presentation, we will introduce two application examples. The first example is the characterization of a bulk single-crystal LiTaO<sub>3</sub>. In this example, we revealed that anomalous C-V curves were observed in the vicinity of domain boundaries. Such C-V curves are considered to reflect domain wall movement due to the electric field. The second example is the characterization of a HfO<sub>2</sub>-based ferroelectric thin film. Since the prepared film had random grain orientations, the shape of the observed C-V curves varied depending on the position. Parameter extraction from the obtained dataset enabled to visualize the in-plane distributions concerning the net switchable polarization amount, the intrinsic coercive field, and the local imprint.

**Keywords :** *Ferroelectric thin film, Scanning probe microscopy, Domain dynamics, Lithium tantalate, Hafnium oxide*

**Conf 03**

**Molecular dynamics in 1- and 2-dimensional nanometric confinement as  
studied by Broadband Dielectric Spectroscopy**

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The question on what length-scale molecular and especially glassy dynamics of low molecular liquids and polymers takes place is of fundamental importance and has multifold practical implications. Recent results based on Broadband Dielectric Spectroscopy [1] for nanometric thin ( $\geq 5$  nm) layers of a variety of polymers [2-6] and even for isolated chains [5] will be presented, delivering the concurring result that deviations from glassy dynamics of the bulk never exceed margins of  $\pm 3$  K *independent* of the layer thickness, the molecular weight of the polymer under study and the underlying substrate. - The experiments lead to the conclusions that glassy dynamics takes place on the length scale a few polymer segments ( $\leq \sim 1$  nm), while the conformation of the chain as a whole is strongly modified by the geometrical confinement [7].

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**Keywords:** *Broadband Dielectric Spectroscopy; nanometric confinement; glassy dynamics, chain dynamics, adsorption*

## **Conf 04**

### **Peculiarities of dipolar ordering in mixed cation halide perovskites Juras BANYS<sup>1</sup>, Sergejus BALCIUNAS<sup>1</sup>, Mantas SIMENAS<sup>1</sup>, Sarunas SVIRSKAS<sup>1</sup>, Martynas KINKA<sup>1</sup>, Vytautas SAMULIONIS<sup>1</sup>, Robertas GRIGALAITIS<sup>1</sup>, Andrius GARBARAS<sup>2</sup>, Anna GAGOR<sup>3</sup>, Mirosław MACZKA<sup>3</sup>, Adam SIERADZKI<sup>4</sup>**

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The methylammonium (MA) lead halides MAPbX<sub>3</sub> (where X = I, Br, Cl) are popular perovskite materials among scientists and industry due to their perspectives in effective and cheap solar cells. During the past decade, the power conversion efficiency of cells based on these hybrid compounds exceeded more than 20%. A high performance of these materials results from several physical properties such as large absorption coefficient, optimal bandgap, long carrier diffusion length, low exciton binding energy, exceptional defect tolerance. However, a successful application of hybrid perovskite solar cells is mainly prevented by their lead toxicity and poor both thermal and water stability.

The most stable and efficient solar cells are obtained by using perovskites with mixed cations at the A-site. The most popular alternatives to MA are formamidinium and Cs<sup>+</sup> ions. A Dimethylammonium (DMA) cation has been introduced recently as an alternative A-site modification for these compounds. Several investigations have shown that during certain synthesis procedures high quantities of DMA may be unintentionally introduced into MAPbI<sub>3</sub> and CsPbI<sub>3</sub>. These modifications stabilize the preferable cubic phase of MAPbI<sub>3</sub> and leads to the enhanced performance at ambient condition.

In the field of classical inorganic perovskites it is well known that mixing may significantly perturb structure of resulting compound. Thus, the long-range order can be suppressed and frustrated phases may appear. The dielectric permittivity behavior of lead halides seem to be especially informative for the performance of the perovskite cells, as their relatively high value of the dielectric permittivity results in a pronounced defect tolerance and low exciton binding energy. However, a complete understanding of mixing effects on the dielectric permittivity dynamics and structural phase behavior is still absent. Here, we present a multitechnique experimental study of the mixed hybrid perovskite MA<sub>1-x</sub>DMA<sub>x</sub>PbBr<sub>3</sub>. Our results show that structural phase transitions are significantly suppressed even for a low substitution of the DMA cations. For higher DMA levels, the long-range dipolar order disappears and dipolar glass dielectric behavior dominates in the dielectric spectra.

**Keywords:** *Dielectric permittivity, halides, solar cell absorber*

**Conf 05**

**Electrospun Nanofibers of High Performance Electret Polymers for Tactile Sensing and Wearable Electronics**

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Bio-Derived Polymers exist in abundance and display diverse chemical compositions, tunable properties, such as high k-dielectric, processability, excellent biocompatibility and biodegradability, with no to minimum toxicity. Such features provide them with capability for futuristic ubiquitous application in networked wearable and tactile electronics as membranes and devices to efficiently scavenge and store operational power from their working environment. Based on our previous work on e-textile, force protection clothing, wearable electronics and electrospun nanofibers, we provide an overview of the recent progress and future applications in textile, e-textile, tactile sensing (sensors, actuators, transistors) and triboelectric devices (batteries, supercapacitors, triboelectric nanogenerators) fabricated using bio-derived natural materials. The diverse structures and fabrication processes of three typical biopolymers provide sustainable pathways that would enable viable self-powering schemes in societally-pervasive applications. Additionally, challenges and potential research opportunities are analyzed and described.

**Keywords:** *biopolymers; tactile; triboelectric; wearable; sensors; high k-dielectric*

**Conf 06**

**Physical - chemical properties of sulfur enriched As-S-Ge glasses related to middle-range order structure**

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Ternary nonstoichiometric chalcogenide glasses in the As-S-Ge system along the tie-line  $(\text{GeS}_4)_x(\text{AsS}_3)_{1-x}$  have been synthesized and characterized by applying XRD analysis, material density and ultrasound propagation measurements. On the basis of the results obtained from density measurements, for each glass composition has been evaluated the molecular weight, average molar and atomic volumes as well as the compactness of the glassy structure. Alongside, the material densities together with experimentally measured velocity of ultrasound propagation in it were used for determination of longitudinal elastic modulus and its compositional dependence. Providing XRD halos analyses the special attention was paid to “first sharp diffraction peak (FSDP)” ascribed to middle range order (MRO) structure of the glassy material. It was revealed that the position of the FSDP nonlinearly shifts with composition change and a maximum of the diffraction angle is clearly derived for glasses comprising about 8 at.% Ge that is composition  $(\text{GeS}_4)_{0,33}(\text{AsS}_3)_{0,67}$ . Applying the Bragg equation to the FSDP peak position of each composition the structural period between MRO domains and its compositional dependence were calculated. From these data followed that the mentioned glassy  $(\text{GeS}_4)_{0,33}(\text{AsS}_3)_{0,67}$  exhibits the minimal inner distance between domains. As these result correlate with compositional dependence of average molar volume, it was concluded that the glasses from the pseudo-binary system  $\text{AsS}_3 - \text{GeS}_4$  containing around 8 at.% Ge have the most “packed” MRO structure. The further increasing of Ge concentration leads to rather sharply boosting of both the average molar volume and inner distance between MRO domains, although finally this increasing tends to saturation. Wherein, it was established that the velocity of the ultrasound propagation reveals the similar compositional dependence, which provides evidence of a direct influence of structural period of the MRO domains on acoustic properties of glassy materials. At that, the compositional dependence of longitudinal elastic modulus better correlates with compositional dependence of compactness of the glassy structure, which is associated with the free volume and flexibility of the glassy network. It was found that among glasses under investigation here the highest compactness and elasticity exhibits the composition  $(\text{GeS}_4)_{0,17}(\text{AsS}_3)_{0,67}$  that comprises 4 at% Ge. The results are explained in terms of deep structural transformation in the middle range order caused by molecular reorganization. The substitution of trifold coordinated As atoms by fourfold coordinated Ge ones leads to a non-monotonic modification of medium range ordering structure, which controls the physical properties, including the elastic ones of the glass.

**Keywords:** *Glasses, Chalcogenides, XRD, FSDP*

**Conf 07**

**Novel therapeutic approach of using herbal Nano powder in Photodynamic therapy (PDT)**

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Photodynamic therapy (PDT) involves administration of tumor localizing photosensitizer agent that produces reactive oxygen radicals during light irradiation and ultimately leads to cell death. There are two well-defined mechanisms for generating cytotoxic species: the first mechanism produces free radicals or superoxide ions resulting from hydrogen or electron transfer; second mechanism is singlet oxygen ( $^1O_2$ ) which generated via an energy transfer process that occurs during collision of excited sensitizer with oxygen. Many photosensitizers such as Photofrin, Hypericin, Lutetium Lexaphyrin, Protoporphyrin IX, Rose Bengal, Methylene Blue, Saffron, ... etc., are already known and some of them are used in vivo. The need to search for natural photosensitizers such as some medicinal herbal materials as a drug substitute are recently received new interest. Moreover, Nano herbal products such as Nanocurcumin is currently used in vitro as a potential photodynamic therapy drug and remains a desirable therapeutic goal. Nano products extracted from herbal is found to be better quantum efficiency, reductions in toxicity and enhancing the killing rate.

**Keywords:** Photodynamic therapy; Natural photosensitizer; Nano herbal; Singlet oxygen; Nanocurcumin

**Conf 08**

**Nanoscale Ferroelectricity in Innovative Lead-Free Oxide Thin Films  
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Many research groups in the world are hardly working on the development, synthesis and characterization of novel ferroelectrics to enhance functional properties for information storage, electronics and spintronics applications. These ferroelectrics include both organic and inorganic compounds. Regarding oxide inorganic materials and for environment, one of the objectives is to replace lead-based compounds such as  $\text{Pb}(\text{Zr}_x\text{Ti}_{1-x})\text{O}_3$  by lead-free compounds showing such as high ferroelectric performances.

In this talk, we will present inorganic oxide materials recently discovered, or/and highlighted, which reveal ferroelectricity at room temperature when they are grown in the form of thin film. We will particularly focus this presentation on  $\text{Ln}_2\text{Ti}_2\text{O}_7$  lanthanide dititanates with double-perovskite structure and  $\text{Ln}_2\text{WO}_6$  lanthanide tungstates. We will demonstrate that strains induced by the substrate in the film can stabilize ferroelectric metastable phases. Besides, piezoresponse force microscopy is known as a powerful technique which permits to access to the domains pattern of ferroelectric sample while its spectroscopic tool yields information about switching properties (ferroelectric properties) and electromechanical activity (piezoelectric properties) at the sub-micron level. We will demonstrate that carefully well-defined experiments have to be achieved to avoid any misinterpretation about existence of ferroelectricity. Some examples of non-ferroelectric compounds, such as  $\text{Nd}_2\text{Ti}_2\text{O}_7/\text{SrTiO}_3$  superlattice, will be reported. Phenomena explaining the non-ferroelectric behaviour in samples will be specified.

We will conclude this presentation by showing that the fabrication of new artificial hybrid materials combining designed inorganic lead-free ferroelectric thin films and electro-active organic polymers can be promising for the emergence of new attractive applications.



## **Conf 09**

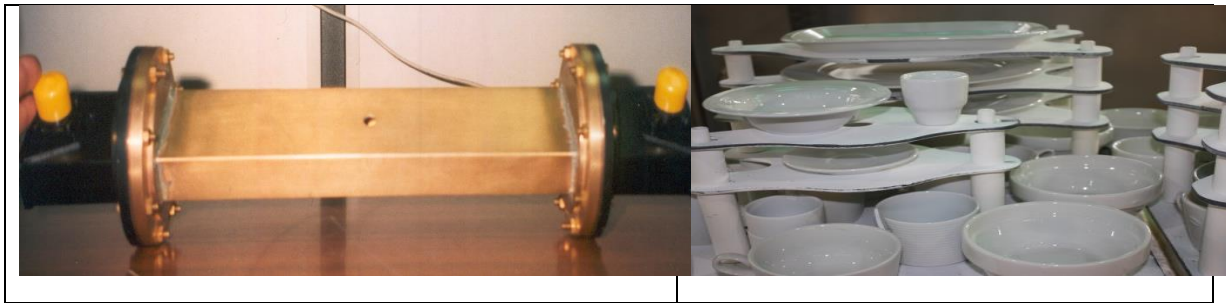
### **Microwave radiation: applications in metrology and materials synthesis**

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Different applications based on microwave radiation can be cited, depending on the power radiation level. For low power levels, in the order of mW, it can be used for the measurement of the electrical properties of materials. The measurement of the complex permittivity can be made using the small perturbation theory. In this method, the resonance peak frequency and the quality factor of a cavity, which are perturbed by the insertion of a sample in the cavity, can be used to calculate the complex dielectric. For high power radiation levels, in the order of kW, it can be used in ovens. Using a multimode cavity, operating at 2.45 GHz, as the only heating source, it is possible to design a microwave oven. Controlling the radiation power, in each stage of the process, it can be produced a more homogeneous electromagnetic field, which is a critical problem in the sintering process using microwave radiation. In this talk, both approaches, low and high power radiations are presented, which can be graphically seen in two different applications in the next figure.



*Figure- Resonant cavity for the measurement of the complex permittivity, and porcelain pieces synthesized in a high power microwave oven.*

## **Conf 10**

### **Nanomaterials and their assemblies: advanced functionalities towards technological applications**

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In recent years, the term “nanomaterials” has almost monopolized the scientific language. At the nanoscale, materials present new and original properties. In this regime, the electronic structures can be tuned by varying the physical size of the nanocrystal (NC), leading to new phenomena, as surface plasmon resonance in metal nanoparticles (NPs) or size-dependent optical transitions in semiconductor quantum dots (QDs), opening interesting opportunities for their exploitation in technological applications. NCs synthesized by means of solution processes represent potential building blocks for cost effective manufacturing of photonic and optoelectronic devices, also on large scale. In particular, colloidal synthetic routes allow to control, in a reproducible manner, size, shape and crystalline phase of the nano-objects. The organic ligands that coordinate NCs play a key role, enabling a careful control on size and shape during the growth, preventing their aggregation, and allowing their versatile processing. By colloidal approaches, NCs of different composition (metal semiconductors, oxides, magnetic NPs, perovskite or carbon based QDs) can be prepared and functionalized with organic molecules which can be also modified after synthesis. Ultimately, the possibility to tune their surface chemistry allows to treat and manipulate the colloidal nanomaterials as macromolecules. The surface chemistry modification is widely exploited for the assembly of NPs, integrated in conventional functional systems or used to manufacture micro/nano devices, showing new properties due to the collective interactions among nanoparticles or with organic molecules [1]. As an example, QDs with controlled size can be coupled in dimeric systems, at nanometric and subnanometric distance, demonstrating efficient energy transfer or wavefunction delocalization processes, depending on their size and interparticle spacing [2,3]. In particular, the control of the geometric parameters of the assembly can strongly influence the coupling efficiency among the QDs and, accordingly, their electronic properties, with possible relapse in photonic or optoelectronic application.

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## **Conf 11**

### **Chemical synthesis of 2D-nanomaterials: Functionalized silicene and phosphorene**

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The design of bi-dimensional (2D) materials has attracted a great attention for their remarkable physical properties in various technological applications. Since facile fabrication processes of large area nanosheets are required for practical applications, a development of soft chemical synthesis route without using conventional vacuum processes is a challenging issue. Techniques for the exfoliation of layered compounds are widely used to fabricate nanometer-thick materials, such as oxides, niobates, chalcogenides, phosphates, and graphene. Although a variety of nanosheets have been synthesized, there have been few reports of silicon and phosphor nanosheets. Mass production of silicon and phosphor nanosheets without conventional vacuum processes and vapor deposition can be achieved using low cost top-down approach starting from materials that comprise a 2D sheet structure as a fundamental unit. Chemical processes provide an alternative route to large-scale synthesis of 2D nanomaterials under production conditions.

Silicon Nano-sheets (SiNSs), low dimensional crystalline silicon materials with their high specific surface area, makes them promising candidates for a variety of applications in nanoscience and nanotechnology. There are two prominent types of SiNSs:

- buckled sheet mainly based on the Si (111) structure, with the same honeycomb lattice structure, but is corrugated due to  $sp^3$  hybridization.
- silicene with a graphene-like honeycomb lattice structure and a mixed  $sp^3$ - $sp^2$  hybridization, that is weakly corrugated.

On the other hand, black phosphorus (BP) was more recently introduced as a new member of the 2D layered material family; it is the most stable allotrope amongst the group also including white, red and violet phosphorus. Black phosphorus, with a graphite-like layered structure, can be effectively exfoliated up to the single atomic layer called phosphorene.

In this perspective, this work focuses on recent progress in soft chemical fabrication of 2D-nanomaterials:

- ✓ silicon nanosheets and their chemical modification,
- ✓ black phosphorus (BP) and its exfoliation to phosphorene.

## **Conf 12**

### **Nanodomains in ferroelectric/dielectric superlattices: a key role in the structural and functional properties**

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Research on nanoscale ferroelectrics evidences that their behaviour is different from that in bulk ferroelectrics, in particular density of the domains and the domain walls increases and plays a key role in the functional properties. For fundamental physics, ferroelectric/dielectric superlattices constitute fascinating objects to understand ferroelectricity at the nanoscale, and to reveal new phenomena with potential for future devices. By alternating individual ultra thin ferroelectric layers with dielectric layers, it is possible to induce ferroelectric nanodomains<sup>1</sup> which are isolated from surface or film-substrate interfaces, and to change the electrostatic domain boundaries as well as the mechanical strain. The polarization discontinuity at the interfaces induces a depolarizing field, and the stability of the polar phase is preserved by forming stripe nanodomains of alternate up and down polarization.

In this talk, we will address some results which illustrate that the presence of ferroelectric nanodomains can lead to the emergence of new phase or can completely change the electric permittivity of a ferroelectric. We will show that a concomitant effect of strains and depolarizing fields in  $\text{PbTiO}_3$ ,  $\text{PbZr}_{0.2}\text{Ti}_{0.8}\text{O}_3$ ,  $\text{SrTiO}_3$  tricolor superlattices can stabilize a monoclinic phase in  $\text{PbZr}_{0.2}\text{Ti}_{0.8}\text{O}_3$  layers<sup>2</sup>. Combined with the electrostatic effect, the tensile strain induced by  $\text{PbZr}_{0.2}\text{Ti}_{0.8}\text{O}_3$  in the  $\text{PbTiO}_3$  layers leads to a polarization rotation associated with a monoclinic Mc phase. In  $\text{PbZr}_{0.2}\text{Ti}_{0.8}\text{O}_3 / \text{SrTiO}_3$  superlattices, we will also show that the ferroelectric capacitance can be stabilized in the negative capacitance region<sup>3</sup>. Negative capacitance has been proposed as way of overcoming fundamental limitations on the power consumption of field-effect transistors<sup>4</sup>, and therefore has recently attracted much attention. The negative capacitance was shown to be strongly related to the existence of ferroelectric nanodomains, in particular, the domain wall motion greatly influences the dielectric properties of the heterostructure<sup>5</sup>.

**Keywords :** ferroelectric materials, epitaxial superlattices, nanoscale, domain structure, strain and electrostatic effects, negative capacitance effect

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**Conf 13**

**Fabrication and Characterization of Single-Crystal Diamond Membranes  
for Photonic Devices**

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The development of quantum technologies is one of the big challenges in modern research and one of the most promising materials is diamond with its color centers in the crystal lattice. A crucial component for many applications is an efficient, coherent spin-photon interface. In order to yield an efficient outcoupling from the zero-phonon line of the color centers and improve the photon collection efficiency, various light-confining architectures can be used like Fabry-Pérot microcavities, nanopillars or photonic crystal cavities. They should be fabricated on thin single-crystal diamond (SCD) membranes with a good quality regarding not only the bulk material, but also its surface. We fabricated SCD membranes with various diameters, exhibiting a low surface roughness down to 0.4 nm on a small area scale, by etching through a diamond bulk mask with angled holes. A significant reduction of pits induced by micro-masking and polishing damages was accomplished by the application of alternating Ar/Cl<sub>2</sub>+O<sub>2</sub> dry etching steps. By a variation of etching parameters regarding the Ar/Cl<sub>2</sub> step an enhanced planarization of the surface was obtained in particular for surfaces with a higher initial surface roughness of several nanometers. We present the successful bonding of a SCD membrane via van der Waals forces on a cavity mirror and perform finesse measurements which yielded values between 500 and 5000, depending on the position and hence on the membrane thickness. Furthermore, photonic crystals were structured in the SCD membranes by electron beam lithography and inductively coupled plasma reactive ion etching with SiO<sub>2</sub> hard mask.

**Keywords :** *Single-crystal diamond, Membranes, Roughness reduction, Nanophotonics*

## **Conf 14**

### **Nanostructured multiferroic Pb(Zr,Ti)O<sub>3</sub>–NiFe<sub>2</sub>O<sub>4</sub> thin-film composites Aleksander MATAVŽ,<sup>1</sup> Primož KOŽELJ,<sup>1</sup> Maximilian WINKLER,<sup>2</sup> Korbinian GEIRHOS,<sup>2</sup> Peter LUNKENHEIMER,<sup>2</sup> and Vid BOBNAR<sup>1\*</sup>**

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The synthesis of multiferroic composite materials rises as an alternative method for simultaneously obtaining ferroelectric and ferromagnetic properties at room temperature with a high degree of magnetoelectric coupling. Compared to bulk composites, thin-films exhibit unique advantages: their composition and connectivity can be modulated at the microscopic scale, which eventually leads to the artificial heterostructures with huge application potential in novel functional devices in the fields of sensors, data storage, and energy harvesters. In composites of spinel ferrites and ferroelectric ceramics – they have up to now been prepared as bulk ceramics or in thin-film configuration as bi- or multi-layers – the magnetoelectric effect arises from direct stress coupling between magnetostrictive (ferromagnetic) and piezoelectric (ferroelectric) grains. It is thus evident that good and extensive connectivity among the constituents might result in significant coupling between piezoelectric and magnetostrictive phases and enhance the magnetoelectric effects.

We present multiferroic thin-film composites with a novel morphology that in fact provides such an extensive connectivity between the magnetostrictive and piezoelectric constituents. They were fabricated by embedding the ferromagnetic NiFe<sub>2</sub>O<sub>4</sub> into self-assembled highly-porous ferroelectric Pb(Zr,Ti)O<sub>3</sub> thin films (the latter themselves exhibit extremely interesting functional properties – the porosity-mediated release of the substrate's mechanical constraints namely boosts their piezoelectric response to the level of bulk ceramics [1]). Detailed structural investigations of developed composites revealed a two phase pure system, without any chemical reaction or solid solubility between both constituents during synthesis. The multiferroicity is clearly evidenced by detecting both ferroelectric and ferromagnetic hysteresis loops at room temperature. Detected magnetic field-induced changes of the dielectric constant, not only at low frequencies but also above the characteristic frequency of the Maxwell-Wagner behavior, reveal a direct stress coupling between the magnetostrictive NiFe<sub>2</sub>O<sub>4</sub> and piezoelectric Pb(Zr,Ti)O<sub>3</sub> grains and imply a great potential utility of the developed material in magnetocapacitive applications [2].

**Keywords:** *Nanostructured films, Thin-film composites, Multiferroics, Magnetoelectrics.*

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## **Conf 15**

### **Physicochemical Characterization of a Novel Carbon Nanomaterial: Carbon Dots**

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Carbon dots (CDs) are a group of novel carbon-based spherical nanoparticles (NPs) with diameters less than 10 nm. They are widely present in the nature and can be also synthesized using various carbon-based substances as precursors by either top-down or bottom-up approaches. They are well characterized for tunable surface functionality, excellent photoluminescence (PL), high photostability and water dispersity, good biocompatibility, and nontoxicity. Also, they display different sizes and surface chemistry depending on the preparation methods and precursors applied. Applications of CDs in drug delivery, bioimaging, sensing, and other nanotechnology fields are rapidly rising due to their aforementioned unique properties. In addition, various spectroscopic and microscopic measurements have been performed on diverse CD preparations, which revealed some typical physicochemical features of CDs. For example, UV/vis absorption spectra of CDs usually display two peaks at 250 and 350 nm, which corresponds to C=C and C=O conjugate structures, respectively. Most fluorescence emission spectra have shown an excitation-dependent PL emission of CDs, which arouses a debate regarding the PL mechanism of CDs. The spherical morphologies of different CDs are studied through a combination of atomic force microscopy (AFM) and transmission electron microscopy (TEM) to obtain the three-dimensional data. As for the structural analysis of CDs, Fourier-transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, X-ray diffraction (XRD), small-angle X-ray scattering (SAXS), and thermogravimetric analysis (TGA) have all been utilized to investigate the surface functionalities and core structures. Considering the abundant functionalities such as -COOH and -NH<sub>2</sub>, distinct CDs were conjugated via an amidation reaction mediated by EDC and NHS to explore the construction of large multifunctional carbon-based nanostructures. Also, zeta potential studies show most CDs carry negative charge on the surface, which inspires numerous researches on the electrical or dielectric properties of CDs.

***Keywords:*** *Carbon Dots, Physicochemical Characterization, Structure, Conjugation, Dielectric properties.*



**Conf 16**

**Influence of synthesis route on morphology and conduction behavior of  
proton conducting electrolytes with perovskite-structure**

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Solid oxide fuel cells (SOFCs) are among the most promising devices running on renewable energy. The electrolyte as a part of the cell plays a crucial role in the cell function. The main requirements for electrolyte materials are: fast proton or mixed conductivity; chemical and mechanical stability in temperature range of operation. These characteristics depend largely on the composition and structure of the material, which in turn are highly sensitive to the method of synthesis. In search of fast conductive electrolytes operating at intermediate temperatures i.e. 300-700 °C, materials with perovskite structure and composition  $\text{BaCe}_{0.8-x}\text{Ti}_x\text{La}_{0.2}\text{O}_{3-\delta}$ ,  $0 \leq x \leq 0.3$  mol% are obtained by two different synthesis approaches: grinding and chemical precipitation reaction. Both regimes are finalized with high temperature sintering for 12 hours. The crystallographic structure is analyzed by X-ray diffraction. In order to reveal any possible differences on the molecular level, their structural arrangement was studied by ATR-Infrared spectroscopy. The results clearly show difference in the spectral characteristics of the materials prepared by the two methods. In addition, the morphology of the samples was studied. The conductivity is examined by electrochemical impedance spectroscopy. This method is very precise and sensitive to all changes that can occur in a material like structural transformations by varying the temperature or conditions (humidity). All the performed investigations in the present work show clear correlation between composition, structure and method of preparation.

**Keywords:** *materials characterization, dielectric materials, energy materials*

## **Conf 17**

### **Cork-based composites for microwave absorbing materials** **BENZERGA R.<sup>1</sup>, KABALAN A.<sup>1,2</sup>, MEJEAN C.<sup>1</sup>, CHAULOUX A.<sup>2</sup> SHARAIHA A.<sup>1</sup>**

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Today, the microwave absorbers usually used in anechoic chambers are made from polymer matrix, such as polyurethane or polystyrene, which are produced by the petrochemical industry [1]. These materials are pollutants and their recycling is often very complicated. In this work, we proposed an original material made from a bio-sourced matrix (cork) [2], acting as a support for the absorbing load (here carbon black). In addition to the rot-proof nature of this matrix and its thermal and acoustic insulation properties, the use of this material was motivated by two other properties: its low density and its fire resistance; two properties necessary for its use in anechoic chamber. In this work, the dielectric characterization of the materials, with different compositions in carbon black, is presented and revealed very interesting dielectric properties with regard to the intended application: namely a low permittivity associated with high dielectric losses. The simulation of pyramidal absorbers, using measured properties, is done in order to choose the best composition for the achievement of a pyramidal prototype. The measurement of the absorber prototype showed excellent absorption performance for a normal and oblique (30°) incidences of the electromagnetic wave. Very low reflection ( $\Gamma < -40$  dB) is obtained over a wide frequency range (between 3.5 GHz and 17 GHz). The prototype of Bio-sourced based absorber also showed, for certain frequencies, better absorption performance than those of a commercial absorber with the same geometry. The temperature and power resistance of these absorbing composites are also studied by simulation and measurement. The results show a much slower rise in the temperature of our material than a commercial absorber one, based on polyurethane foam.

**Keywords :** *Bio-sourced composite, electromagnetic absorption, carbon particle, anechoic chamber, reflection loss.*

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**Conf 18**

**Adhesion analysis of non-woven hybrid cotton fibers in unsaturated polyester by dielectric spectroscopy**

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Dielectric measurements have been undertaken in the temperature range 0-150°C and the frequency range 0.1 Hz - 1 MHz on three non-woven hybrid cotton fibers reinforced unsaturated polyester composites (#1, #2 and #3). These latter differ either by the relative volume fractions of white yarns and indigo denim fabrics which are the constituents of the reinforcement or by the number of passages in the industrial needle punching for the mechanical consolidation of the non-woven reinforcement. The white yarns/indigo denim fabrics relative volume fractions 1:3 and 1:1, are used for the composites #1 and #2, respectively. Whereas, for the composite #3 which has the same relative volume fraction to the one for the composite #2 differs by the number of mechanical consolidation in comparison with the former composites. The dielectric analysis has revealed the presence of two interfacial polarization effects and the  $\alpha$  relaxation at high temperature according to Kramers-Kronig relation. Analysis of these dielectric relaxations by means of the Havriliak-Negami model has evidenced the effect of the reinforcement constituent relative volume fractions and that of the mechanical consolidation on white cotton fibers/unsaturated polyester and indigo cotton fibers/unsaturated polyester adhesions. A comparative dielectric study allows probing the better reinforcement conception conditions for the better reinforcement/matrix adhesion.

***Keywords :*** *Non-woven cotton fibers ; unsaturated polyester composites ; dielectric relaxation ; interfacial polarization effect.*

**Oral Presentations**  
**(Session A)**

## OP-A02

### Investigating the nanoscale physical properties of electroactive PVDF-based nanocomposites

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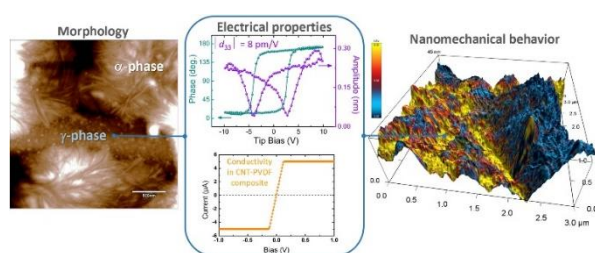
Polymers with electroactive properties provide numerous opportunities for applications in domains such as biomedicine or energy generation owing to their low-cost, easy processing, flexibility, and biocompatibility compared to ceramic counterpart. The poly(vinylidene fluoride) (PVDF) is a semi-crystalline polymer with excellent piezo-, pyro- and ferroelectric properties allowing its application as sensors, actuators and flexible energy harvester systems. In addition, the inclusion of ceramic nanoparticles is an interesting way to improve physical properties of such fluoropolymers. Consequently, probing the response of the nanometric fillers dispersed in the polymer matrix becomes fundamental in order to optimize macroscopic performance of devices based on such piezocomposites. This crucial step thus requires the use of Atomic Force Microscopy (AFM) and their advanced modes, enabling to gain access to the physical properties of the nanocomposites with nanoscale resolution.

In the present study, both carbon nanotubes/PVDF and stretched barium titanate (BaTiO<sub>3</sub>)/PVDF nanocomposites were studied. Based on several AFM modes, such as Tapping AFM for surface morphologies, Piezoelectric Force Microscopy (PFM) for piezo-/ferroelectric properties, conductive-AFM for electrical conductivity and amplitude modulation–frequency modulation (AM-FM) method for nanomechanical behavior, a deep investigation on the microstructure and physical properties of the composites was performed on the nanoscale in addition to macroscopic studies. The significant results are: (i) the direct identification of  $\alpha$ - and  $\gamma$ -phases of the PVDF successfully achieved (Figure), enabling better understanding of the impact of the carbon nanotubes on the structural and functional properties of the PVDF-based nanocomposites [1]; and (ii) the ability of the PFM tool to directly image individual piezoelectric nanometric fillers embedded into a polymer matrix and control polarization as well [2], allowing for in-depth nanoscale study of electroactive composites.

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**Keywords:** PVDF-based nanocomposites; Nanoscale piezoelectricity; Atomic Force



### Microscopy

The local behavior of PVDF  $\gamma$ -phase induced by carbon nanotube incorporation has been investigated by AFM-based techniques [1].

**OP-A03**

**Role of composition on the electrocaloric properties of  $\text{BaM}_x\text{Ti}_{1-x}\text{O}_3$  ceramics**

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In the last years, there is a high interest in developing alternative cooling technologies because: (i) it is important to reduce greenhouse gases that are used heavily in domestic and industrial refrigeration; (ii) high current densities in integrated circuits impose higher demands on cooling systems that cannot met by the fan-based solutions. The main advantage of electrocaloric (EC) refrigeration is that by comparison with magnetocaloric solid-state refrigerators based on another solid-state cooling technology, the big-sized magnet is still a drawback.  $\text{BaTiO}_3$  (BT) family as EC materials has been studied quite extensively in the past several years in various forms including thin films, bulk ceramics (also multilayer ceramic capacitors -MLCC) and single crystals and a large  $\Delta T$  has been reported for BT-ceramics in the vicinity of ferroelectric-paraelectric (FE-PE) (tetragonal-cubic T-C) phase transition. Owing to the high transition temperature the using of pure BT as EC materials is limited, but this can be properly modified by incorporation of suitable dopants. In the present work we proposed to study the composition dependence of ECE in  $\text{BaM}_x\text{Ti}_{1-x}\text{O}_3$  ( $\text{M}^{4+}=\text{Zr}/\text{Hf}$ ) ceramics with composition from ferroelectric ( $x=0.02-0.08$ ) to relaxor ( $x=0.20-0.30$ ). Ceramics were obtained by sintering at  $1500^\circ\text{C}$  the powders prepared by solid state method. X-ray diffraction data showed the phase purity and SEM images demonstrated homogeneous microstructures (average grain size between  $10-5\ \mu\text{m}$ ) and well-defined grain boundaries. Impedance spectroscopy in the temperature range of  $(25\ \text{to}\ 150)^\circ\text{C}$  shows a composition-induced ferroelectric-to-relaxor crossover with compositional-dependent shifts of the structural transition temperatures by comparison with ones of the pure  $\text{BaTiO}_3$ . Polarisation vs. E loops indicate regular variation with increasing  $\text{M}^{4+}$  addition, a reducing of loop area, remanent and saturation polarization (when  $\text{M}^{4+}=\text{Zr}$  from  $P_{\text{sat}}=15\ \mu\text{C}/\text{cm}^2$  to  $P_{\text{sat}}=9\ \mu\text{C}/\text{cm}^2$ ). ECE was indirect evaluated from P(E) loops with temperature and in case of Zr addition a maximum of  $0.7\ \text{K}$  was obtained for  $x=0.04$  at  $373\text{K}$ .

**Acknowledgement:** *This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI – UEFISCDI, project number PN-III-P1-1.1-TE-2019-1689, within PNCDI III*

**Keywords:**  *$\text{BaTiO}_3$  solid solution, ferroelectric-relaxor crossover, electrocaloric effect*

**Oral Presentations**  
**(Session B)**



**OP-B01**

**Effect of Nanostructuring on Thermoelectric Properties of Polymer  
Nanocomposites**

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Thermoelectric (TE) materials are well known for their ability to convert waste heat into electricity<sup>1</sup>. So far, inorganic TE materials like Bi<sub>2</sub>Te<sub>3</sub>, PbTe, SnSe gained much attention due to their high TE *figure of merit* i.e.  $zT$  values. However, their low earth abundance, toxicity, high cost, and hideous processing make it difficult to serve large scale applications<sup>2</sup>.

In order to achieve a high  $zT$  values, TE parameters, namely, electrical conductivity, thermal conductivity, and Seebeck coefficient are needed to be optimized. However, these parameters are interdependent on each other in the bulk state and a change in one parameters can have a huge impact on the other. Nevertheless, this interdependency vanished at nanoscale, which means nanostructuring of materials could be helpful to attain high  $zT$ <sup>3</sup>.

We have synthesized poly (3,4-ethylene dioxythiophene): polystyrene sulfonate (PEDOT: PSS) matrix filled with graphene oxide-titanium dioxide (GO-TiO<sub>2</sub>) nanostructure and the effect of nanostructure on the TE properties has been investigated. It has been evident that the GO-TiO<sub>2</sub> nanostructure succeed to break the interdependency by enhancing electrical conductivity and Seebeck coefficient in parallel to the decrement in the thermal conductivity and as a result, an improved  $zT$  values has been attained.

**Keywords:** *Thermoelectricity, nanostructures, thermal conductivity, electrical conductivity, Seebeck coefficient*

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## **OP-B02**

### **Processing high permittivity rutile TiO<sub>2</sub> for all-dielectric metamaterials applications at terahertz frequencies**

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We aim to realize All-Dielectric Metamaterials (ADM) operating in the THz range[1]. ADMs are structured dielectric materials, whose unit cell comprises two sub-wavelength building blocks, that may be 2D or 3D. Indeed, ADMs rely on the first two modes of Mie resonances of High Permittivity Resonators (HPR). Their unit cell is of simple geometry. HPRs at a few tens of microns scale are required for ADMs applications in the Terahertz (THz) range.

THz radiation is widely defined as the electromagnetic radiation in the frequency range 0.3 -10 THz. It allows to obtain physical data that are not accessible by the means of X-rays or infrared radiation. Besides, ADMs allow to achieve a great number of fascinating phenomena, (see [2] for a review).

In this work, the dense TiO<sub>2</sub> ceramics with high permittivity and low dielectric losses has been obtained from powders by Spark Plasma Sintering method. We have studied the influence of the size of the grains, the temperature of SPS and the conditions of the post-annealing, on the dielectric properties of materials in the 0.3-1.5 THz range.

Then, the samples were characterized at THz frequencies by the means of Time Domain Spectroscopy. The optimized dielectric constant was measured in the 0.3-1.5 THz range: the relative permittivity  $\epsilon'$  is around 100, while the dielectric losses linearly increase with frequency from  $\tan\delta = 0.01$  to 0.1. These results are in good agreement with those of ref.[3] and are suited for the realization of ADMs. This behavior is also in good agreement with the semi-quantum model [4]. In a further step, this bulk ceramic will be micro-structured *via* micro-moulding so as to realize the ADMs. Polymer and quartz moulds will be etched. Our goal is to develop metadevices, i.e., efficient functional devices that take advantage of the fascinating properties of metamaterials.

**Keywords:** *Dielectric materials, THz-TDS, Metamaterials, low dielectric losses*

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**OP-B03**

**Coping with the poor conductivity of organic semiconductor liquid crystals via carbon-dots dispersion**

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Organic semiconductor liquid crystals (OSCLCs) have recently gained immense interest in the field of organic electronics. The 2,3,6,7,10,11-hexaalkoxytriphenylene (HAT-8) discotic liquid crystal, exhibiting a hexagonal columnar (Col<sub>h</sub>) phase, served as OSCLCs due to its appealing charge carrier mobility of the order of 10<sup>-4</sup> cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> [1]. Often, these OSCLCs suffer from low conductivity, which restricts their use as an active material for organic devices [2]. To overcome this problem, we have dispersed carbon dots (C-dots) of size 7-8 nm (in diameter) to the host HAT-8 matrix into different concentrations. The HAT-8/C-dots composites have been characterized using dielectric spectroscopy, polarized optical microscopy and the time-of-flight technique. The dielectric results revealed that the conductivity of the pristine HAT-8 has been enhanced with the addition of C-dots as a function of their dispersion concentration (Figure 1). This enhancement in conductivity is attributed to the change in the molecular ordering of the discotic mesogens. The obtained results evince that the HAT-8/C-dots composites could serve better for organic electronic and optoelectronic applications.

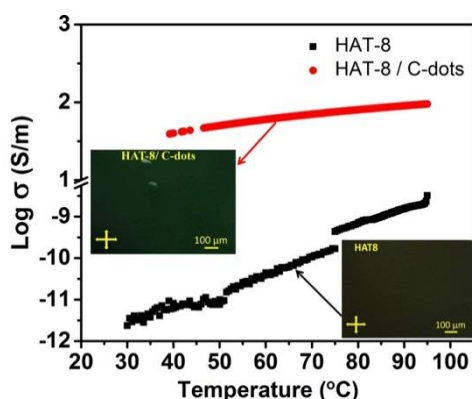


Figure 1. The variation of log  $\sigma$  as a function of temperature for the pristine HAT-8 and HAT-8/C-dots composite. Insets represent the corresponding polarized optical micrographs.

**Key words:** Discotic Liquid Crystals, Carbon-dots, Mobility, Conductivity and Dielectric property

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**OP-B04**

**Control, quantification, and mapping of elastic strains in epitaxial ferroelectric BaZrO<sub>3</sub>/BaTiO<sub>3</sub> superlattices**

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Ferroelectric superlattices (SLs) composed of alternating layers of different thin films are fascinating nanostructures that have attracted a great interest in the last decade, due to their superior physical properties suitable for many modern applications. The strain engineering is one of the tools giving rise to an enhancement of functional properties in SLs and usually leading to new ferroelectric properties. The strain is controlled by varying the SLs modulation period and the ratio of layer thicknesses of the alternating materials.

In this work, we present the control and quantification through strain mapping of the elastic strain in artificial BaZrO<sub>3</sub>/BaTiO<sub>3</sub> (BZ/BT) superlattices grown on oxide substrates using pulsed laser deposition technique. The methodology consists of a combination of high-resolution scanning transmission electron microscopy and nanobeam electron diffraction associated with dedicated algorithm for diffraction patterns processing originally developed for semiconductors to record the strains at atomic scale. Both in-plane and out-of-plane elastic strains were then determined at 2 nm spatial resolution and their average values were used to map the strains along and transverse to the epitaxial growth direction to determine its variation along several BZ/BT interfaces. In addition, the variation of the width of the inter-diffusion BT/BZ interfaces and intermixing between different layers are estimated. The effect of the presence of inter-diffusion interfaces and the inherent elastic strains on the functional properties (dielectric, ferroelectric, energy storage, etc...) of the BZ/BT SLs are evaluated and discussed [1].

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**Oral Presentations**  
**(Session C)**

## **OP-C01**

# **Recording Medium Design Aiming at Realizing Ferroelectric Probe Data Storage**

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Ferroelectric probe data storage is a novel data storage method, which uses ferroelectric materials as a recording layer. In this method, digital data bits are recorded by nano-scaled polarization reversal. Extremely small domain dots (diameter of less than 10 nm) can be formed using ferroelectric thin films and nanoscale probe tip. Up to now, a domain dot array with an areal recording density of 4 Tbit/inch<sup>2</sup> has been written on a single-crystal LiTaO<sub>3</sub> recording medium to demonstrate its potential. This novel method, however, has a problem of low reading speed. Up to now, we have reported 3.7 Mbps readout demonstration using thin-film PZT recording media. Although this achieved readout speed is much higher than other probe data storage techniques, there is a significant gap between the current and the required specifications.

To overcome this problem, a novel ferroelectric recording medium with large nonlinear permittivity is required, because this data storage method uses the nonlinear dielectric response induced by small-amplitude ac bias to detect the bit data recorded in the form of polarization direction. Thus, we examined nonlinear permittivity based on phenomenological theory from the viewpoint of data storage application. We revealed that Curie-point control is one of the key techniques in material design for our application because nonlinear permittivity increases precipitously with approaching to the Curie temperature as with linear permittivity and piezoelectric constants. On the other hand, we also revealed that there is a trade-off relationship between nonlinear permittivity and polarization stability. To avoid this undesirable situation in data storage application, pinning-site control will also be important. Additionally, we also propose to employ a double-layer structure in the ferroelectric recording media for further improvement.

**Keywords :** *Probe data storage, Nonlinear permittivity, Phenomenological theory, LiTaO<sub>3</sub>*

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**OP-C03**

**Modeling of the dielectric properties in ferroelectric-based composites by  
Finite Element Method**

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Since single-phase ferroelectric materials cannot accomplish all the technological requirements in applications, developing composite materials that combine the properties of the ferroelectrics with other constituent phases (linear dielectrics, magnetic materials or other conductive/semiconductor components) is a commonly proposed solution. Recently, it has been shown by Finite Element Method simulations that a major factor that influences the effective properties of composite materials is the local electric field inhomogeneity introduced by the interfaces. Based on this effect, we proposed the original concept local field engineering which involves the design of materials with controlled microstructures and, implicitly, an optimum inhomogeneity of the electric field to improve the functional properties [1,2].

Another important factor that influences the functional properties of composites is the accumulation of free charges at interfaces, but this has been neglected so far because it involves important computational difficulties. In this work we propose a new modelling dynamic approach based on finite element method able to describe the complex impedance at any frequency in the range from 1Hz to 1MHz. The approach allows us to explore the influence of free electric charges on the effective dielectric properties of real composite systems. To demonstrate its generality, the new dynamic approach was implemented in this work to describe different types of ferroelectric-based composites: with conductive inclusions, magnetoelectric composites and porous ceramics.

**Acknowledgements:** This work was supported by the UEFISCDI Romanian projects PN-III-P1-1.1-TE-2019-1929 and PN-III-P4-ID-PCCF2016-0175.

**Keywords:** *Finite element method, Effective dielectric properties, Composites, Ferroelectrics*

**References:**

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## OP-C04

### Study of the aging of Lithium-ion coin cells with impedance and noise measurements.

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In this work, we study the aging of lithium-ion coin cells by performing successive cycles of charging and discharging until the battery cannot be utilized. We perform different duration of discharging (and charging): short (30 mins), average (2h) and long (20h).

This study is carried out using the electric impedance and noise measurements in wide range of frequency typically from 0.01 Hz to 1 MHz. Figure 1 presents a complex impedance diagram  $Z^* = Z' + iZ''$  under the form of  $-Z'' = f(Z')$  parameterized in frequency. The first part, ranging from 0.01 Hz to 0.16 Hz, represents the diffusion of lithium ions in the battery. The second part (0.16 Hz to 88 kHz) depicts the electrochemical reactions taking place inside the battery. Finally, the values above 88 kHz constitutes the last part of the impedance spectrum, which reveals the artifacts of electric measuring wires (extrinsic effect of the battery).

In the context of this work, we notice that the aging leads to a strong increase of the resistance  $R_p$  but not in the resistance  $R_0$ . At the same time, the capacity (mAh) decreases strongly and tends towards 0 when the battery is out of order. In addition, noise measurements show the evolution at low frequencies of the noise level in  $1/f^\gamma$  ( $1 < \gamma < 2$ ).

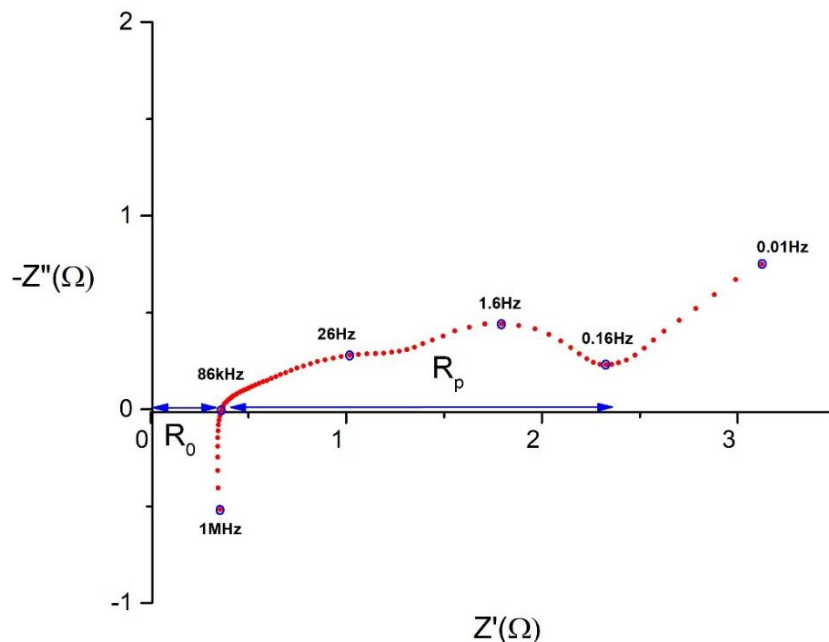


FIGURE 1: IMPEDANCE DIAGRAM FOR LITHIUM-ION CELL

**Keywords:** Lithium-ion, Battery, Cycles, Impedance, Noise, Electrochemical reactions.

**OP-C05**

**Optimization of (Ba,Ca)(Zr,Ti)O<sub>3</sub> lead-free piezoelectric ceramics  
properties by variation of the composition**

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PbZr<sub>(1-x)</sub>Ti<sub>x</sub>O<sub>3</sub> (PZT) show piezoelectric properties ( $\approx 700$  pC/N) and a Curie temperature ( $\approx 360^\circ\text{C}$ ) much higher than other piezoelectric ceramics. Yet, PZT are associated to many health and environmental problems linked to the lead it contains. It is thus crucial to turn to so called “lead-free” ceramics. Among the alternatives, one is the family of barium and calcium zirconate-titanates (Ba<sub>1-x</sub>Ca<sub>x</sub>)(Zr<sub>y</sub>Ti<sub>1-y</sub>)O<sub>3</sub> (BCTZ). These compounds have very promising piezoelectric properties, but a low Curie temperature. They have fewer applications than PZT but they can still be used at low temperatures as sensors or for energy harvesting, for example.

In this work, focus was first put on the composition (Ba<sub>0.85</sub>Ca<sub>0.15</sub>)(Ti<sub>0.90</sub>Zr<sub>0.10</sub>)O<sub>3</sub> as reference, and the Zr/Ti ratio ( $y/(1-y)$ ) on one hand and the Ca/Ba ratio ( $x/(1-x)$ ) on the other hand were then varied. The aim was to finely modulate the piezoelectric properties. Each composition was characterized by X-ray diffraction and scanning electron microscopy. The piezoelectric, ferroelectric as well as dielectric properties were also studied.

This work made it possible to highlight a  $d_{33}$  piezoelectric coefficient varying from  $\sim 250$  pC/N to 450 pC/N, as well as a Curie temperature reaching  $90^\circ\text{C}$  for some compositions. The ferroelectric properties improve with when both  $x$  and  $y$  decrease,  $P_r$  attaining a maximum value of  $\sim 9.0$   $\mu\text{C}/\text{cm}^2$  for  $x = 0.13$  ( $y = 0.10$ ) and  $\sim 9.1$   $\mu\text{C}/\text{cm}^2$  for  $y = 0.08$  ( $x = 0.15$ ).  $P_s$  also shows maximum values of  $\sim 18.7$   $\mu\text{C}/\text{cm}^2$  and  $\sim 18.8$   $\mu\text{C}/\text{cm}^2$  for the same compositions.

**Keywords:** *BCTZ, X-rays powder diffraction, Ferroelectric materials, Dielectric materials, Piezoelectricity.*

## OP-C06

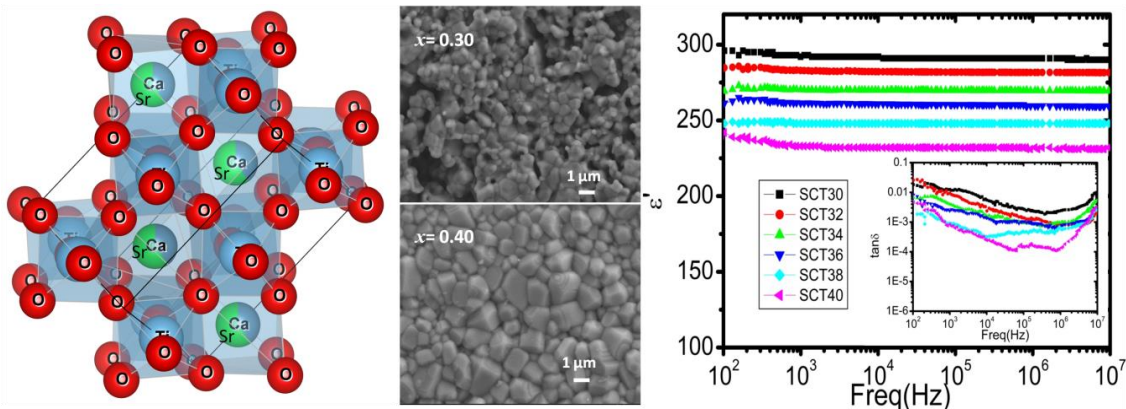
### Structural, morphological and frequency dependent dielectric properties of $\text{Sr}_{1-x}\text{Ca}_x\text{TiO}_3$ ( $0.30 \leq x \leq 0.40$ ) ceramics

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In pulsed power circuits, dielectrics based electrostatic capacitors are indispensable components, resulting in a wide range of applications. The applications include but are not limited to energy storage, AC/DC converters of hybrid electric vehicles, medical devices, and military weapons [1]. Strontium calcium titanate ( $\text{Sr,Ca}$ ) $\text{TiO}_3$  (SCT) solid solutions are a promising class of materials to design high-performance lead-free dielectric capacitors. This is primarily attributed to the fact that the Ca dopant improves the electric fields, temperature and frequency stabilities of  $\text{SrTiO}_3$  ceramic. Here, we report the structural, microstructural and frequency (100 Hz to 10 MHz) dependent dielectric properties of sol-gel derived  $\text{Sr}_{1-x}\text{Ca}_x\text{TiO}_3$  ( $0.30 \leq x \leq 0.40$ ) ceramics. It has been found that the Ca doping concentration in the  $\text{SrTiO}_3$  lattice played a significant role in structural, microstructural and dielectric evolution. The grain size increased ( $\sim 0.8 \mu\text{m}$  to  $2 \mu\text{m}$ ) and the shape of the particles tends to be defined with an increase in Ca doping concentration. This implies that the grain growth is promoted with  $\text{Ca}^{2+}$  addition as a result of liquid phase sintering (growth is usually isotropic) [2]. The dielectric constant ( $\epsilon'$ ) declined as the doping concentration increases ( $\sim 290$  to  $230$ ). This could be due to the lower atomic polarizability of  $\text{Ca}^{2+}$  ( $106 \pm 4$ ) than  $\text{Sr}^{2+}$  ( $197 \pm 2$ ) [3]. In the measured frequency range, the  $\epsilon'$  of all samples has been found to be stable. This indicates that SCT ceramics possess good frequency stability. Dielectric loss tangent decreased down to  $< 2 \times 10^{-4}$  at 1 MHz frequency as the doping concentration increases. This is valuable for the dielectric materials in realistic applications.



**Keywords:** Sol-gel, doping, lead-free dielectric ceramics and energy storage.

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**OP-C07**

**Ultra-porous composites based on epoxy foam loaded with carbon fibers  
for microwave absorption**

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Recently, a great progress has been reached in the development of new microwave absorber materials to meet the new requirements of different application domains. For a broadband frequency absorption, the porous composites are among the top absorber materials that gained much interest in the microwave domain.

In our team, a new electromagnetic (EM) absorber made from rigid epoxy foam filled with a very low concentration of carbon fibers (CFs) is developed. This solution has been proposed to overcome the inconvenient of the flexible polyurethane foam currently available and used in the anechoic chamber. Our results show a very good absorption performance for our materials compared with the commercial one; however, the density of the proposed material remains a constraint that must be optimized.

In this work, a simple method was proposed to fabricate lightweight CFs/epoxy foam composites with a very high EM absorbing performance; the composite density can be controlled via proper proportioning of components constituting the absorber material.

Samples with different densities and CFs loads are elaborated and characterized in free space in order to investigate the influence of these parameters on the structure and on the dielectric properties of composites. Our results show that the material density can be reduced by one third compared to the normal density of epoxy foam. In addition, the real part of permittivity of the elaborated composites is reduced, due to the presence of more porosity, while maintaining a very high level of dielectric losses, which is very promising for the elaboration of EM absorbing materials.

Finally, suitable properties that ensure an impedance gradient are selected to make a multilayer absorber prototype. The simulation and measurement of this very lightly loaded absorber were compared, in 2-16 GHz frequency band, to those of the dense CFs/epoxy foam multilayer and of commercial multilayer absorber.

**Keywords:** *Carbon fiber, dielectric materials, epoxy foam, lightweight composites, microwave absorption*

**Oral Presentations**  
**(Session D)**

## OP-D01

# Hybrid thin Films based Phototransistor Optimized by Dynamic Floating Film Transfer Method

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Organic phototransistor have gained significant research interest owing to their prospective application in society, such as in security, military, health monitoring devices. The number of organic semiconductors including small molecules and conjugated polymers have been used for fabrication of organic phototransistor and reported high responsivity in some materials [1]. From the recent report composite materials by blending the p-type polymers and inorganic nanoparticle have been used for organic phototransistor application due to high charge generation/separation with appropriate driving force such as electron donor – acceptor systems. We have studied poly (3-hexyl thiophene) and ZnO nanorods based composite oriented thin film for phototransistor application after fabricating the OFETs. For this study, first hybrid thin film is prepared by recently developed ribbon-shaped Floating film Transfer Method (FTM) [2]. The hybrid film morphology was investigated by polarized optical microscopy and AFM. Quantitative investigations of film orientation were done by measuring the dichroic ratio (DR). Large area of hybrid thin films up to 20 cm in length and 2 cm in width show a DR= 2 with more than 7 nm redshift wavelength as compared to pristine film. The maximal oriented hybrid films were used as active semiconductor material in the OFETs channel to study their photoresponse properties. The OFETs are characterized under the dark and after the light illumination. Hybrid OFETs show high charge carrier mobility up to  $\mu = 0.009 \text{ Cm}^2/\text{V s}$  over the pristine. Further, OFETs observed under light illumination ( $\lambda = 450 \text{ nm}$ ,  $P_{\text{in}} = 0 \text{ to } 0.5 \text{ mW/cm}^2$ ) and show the drain current proportionally increased with  $P_{\text{in}}$  due to the photogeneration in addition to the field effect current (figure 1). The amplified drain current indicates improved photosensitivity and responsivity.

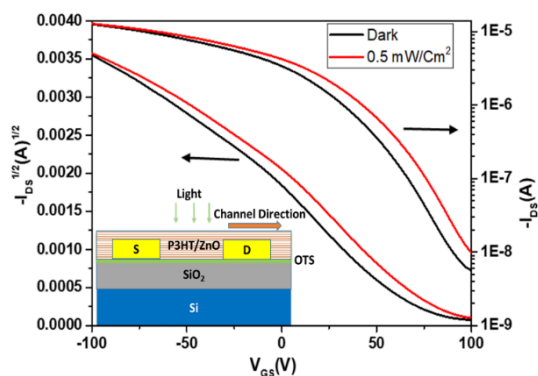


Figure 1. Transfer characteristics of Hybrid phototransistor measured under light illumination from the light intensity 0 to 0.5 mW/cm<sup>2</sup>.

**Keywords:** Hybrid phototransistor, P3HT, ZnO nanoparticle, Floating film transfer method.

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**OP-D02**

**Theoretical and experimental investigation of BFO-based nanomaterials for photocatalytic applications**

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Harnessing sunlight to produce hydrogen on demand is regarded as an ingenious way to produce alternative clean energy and meet the world's energy needs. In recent years, perovskite materials have emerged as potential photocatalysts owing to their high electrochemical and photophysical properties allowing the design of water splitting devices with high solar to hydrogen efficiency. BiFeO<sub>3</sub> (BFO) material is regarded as a potential material for photocatalysis owing to its moderate band gap of 2.7 eV enabling visible light absorption, in addition to its ferroelectric properties which could be used to control the separation of the photogenerated charge carriers. However, the sole use of the BFO system as a catalyst limits its performances owing to its weak redox ability. Therefore, our approach is to use solid-solutions based on the BFO system to improve the catalytic performances. Furthermore, the design of nanomaterial catalysts has been reported to exhibit higher catalytic performances over their bulk counterpart owing to their increased specific surface area, and effective transfer rate of electrons-holes to the surface of the photocatalyst. Within this scope, the aim of the present work is to develop low-dimensional functional BFO-based materials having unique physical properties for applications related to hydrogen energy production. Two complementary approaches were used to choose and develop the optimal BFO-based composition presenting the best properties for photocatalysis. As a first stage, computational modeling and materials optimization were performed through first principles calculations to investigate the electronic, optical, and photocatalytic properties of different BFO-based materials. Then, and supported by theoretical results, their synthesis was performed through different techniques to elaborate composite materials having both band gap  $> 1.8$  eV necessary to split water molecules, and intrinsic polarization to separate the generated charge carriers.



### **OP-D03**

## **Structural, morphological, and dielectric properties of BaSnO<sub>3</sub> bulk ceramics and thin films.**

**S. CHAHIB<sup>1,2\*</sup>, D. FASQUELLE<sup>1</sup> AND G. LEROY<sup>1</sup>**

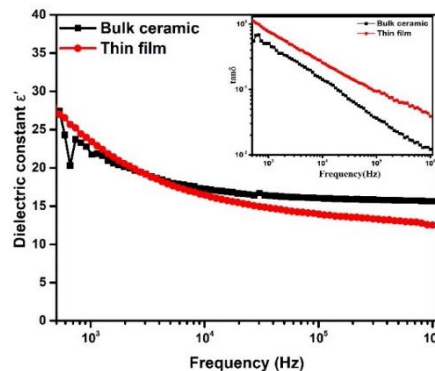
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BaSnO<sub>3</sub>-based material is considered as a paraelectric material [1]. It has been used to fabricate thermally stable capacitors [2]. This compound has an excellent thermal stability [3]. The aim of this work is to study the frequency-dependent dielectric properties of bulk ceramics and thin films forms of BaSnO<sub>3</sub>. For this purpose, the bulk ceramics have been synthesized using the well-known Sol-gel method, while the thin films have been grown using spin-coating technique on Pt/Ti/Si/SiO<sub>2</sub> substrate. The XRD diffraction spectra of ceramics and thin films of BaSnO<sub>3</sub> showed the cubic perovskite structure. Thin films have been grown with (110) preferred orientation. The SEM showed that grain size for ceramics is ranging from 3.7 μm to 7.2 μm whereas for the surface of thin films is composed of particles with a size between 65 nm and 76 nm. The AFM images showed that the BaSnO<sub>3</sub> thin films have a high surface quality. The dielectric properties and AC conductivity of this compound were investigated in the frequency range (20 Hz- 1MHz). The dielectric constant has been found to be around 17 and 13 at 1MHz for the bulk ceramics and thin films, respectively. The tangent loss has been determined to be ~0.0125 and 0.038 at 1MHz for ceramics and thin films, respectively. The present study signifies that the dielectric properties of BaSnO<sub>3</sub> ceramic have effectively been transferred to the thin films form, which is essential for technologies that are dedicated to electronics.

**Keywords:** BaSnO<sub>3</sub>, Dielectric properties, AC conductivity, Sol-gel, and Spin-coating.



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**OP-D04**

**Piezoelectric properties of biobased poly(L-lactide) stretched films for energy harvesting applications**

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This study aims to explore the intrinsic shear piezoelectricity of biobased poly(L-lactide) (PLA) for energy harvesting [1,2]. PLA is a cheap, abundant and non-toxic material [3].

In this work the production of PLA films was carried out by single-screw extrusion, followed by a uniaxial stretching.

Piezoelectric measurements were done to allow quantification of the piezoelectric shear response of PLA films. In addition, the energy harvesting measurement have allowed to compare harvesting power from our different PLA films. Afterwards, an electromechanical model was developed to analyze the effect of different parameters on the electric power.

Consequently, shear piezoelectric properties could be easily developed and optimized for stretched PLA films using conventional processing tools without any electrical poling step. Such biobased materials clearly open new perspectives into cost-effective energy harvesting solutions for low-power electronics.

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## **OP-D05**

### **Morphological characterization of innovative GaN passivation: insights into Normally-off MOS Capacitors**

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Devices based on GaN, particularly high-electron-mobility transistors (HEMTs), are attractive candidates in the renewable energy segment that needs increasing conversion efficiency and power density. The benefits of GaN-based power devices are numerous: fast switching speed, low On-resistance, high breakdown voltage and excellent manufacturing capability. Nevertheless, currently manufacturing normally-off devices remains challenging<sup>1</sup>.

In this work, we investigate the interesting solution of High Electron Mobility Transistors with a fully recessed gate Metal-Insulator-Semiconductor structure (MIS-HEMTs) *via* an Al<sub>2</sub>O<sub>3</sub>/AlN/GaN MOS Capacitor. In particular, the role of substrate biasing during the GaN passivation with AlN deposited by Plasma Enhanced Atomic Layer Deposition (PEALD) was studied<sup>2</sup>. It's well known that environmental conditions during the thin film growth can significantly change the microstructure of the deposited film, and the crystallographic modulation in the film can be directly correlated to the electrical characteristics.

A complete set of physical analyses (pARXPS, DRX, TEM) is presented, to investigate the modifications of the AlN film with respect to deposition conditions. It clearly shows differences in terms of crystal structure, crystallinity, texture and elemental composition, from an epitaxial crystalline layer to an amorphous and rough film. A narrow bias window is found where the GaN passivation is significantly improved compared to a standard AlN film deposited without bias. This leads to a positively shift of the flatband voltage of the C-V characteristics while preserving high AlN/n-GaN interface quality.

Therefore, innovative engineering of the insulator deposition process provides a promising pathway towards the manufacturing of normally-off MOS-channel High Electron Mobility Transistors.

**Keywords :** *Physical characterization – aluminium nitride - MOSc-HEMTs - PEALD growth*

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**Oral Presentations**  
**(Session VA)**

## **OP-VA01**

### **Electronic structure of defected polyethylene for Schottky emission**

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Polyethylene (PE) is one of the most used solid state insulators in electrical power industry. It is especially used to electrically insulate high-voltage cables. Under the stress associated with AC power supplies, this material undergoes ageing, which is often associated with treeing<sup>[1]</sup>. It is thought that this phenomenon starts from gaseous defects embedded in the insulator bulk, leading to the formation of a cluster of cavities. Treeing is able to dig the matrix until complete breakdown of the insulating components. Cavities are generated by a sequence of partial discharges (PDs). Each PD is triggered by an electron emission from PE into the gas. The Schottky effect (SE) is believed to be the most likely mechanism able to cause this emission<sup>[2,3]</sup>.

Several experiments reproducing treeing propagation or even PDs in isolated voids, using industrial AC power supplies, have revealed that one (or more) discharges take place for each period<sup>[4]</sup>. This poses a lower bound to SE, since a sufficient number of electrons must be ejected from PE during each oscillation period.

In this work, we have characterized, with density functional theory (DFT) calculations, the electronic structure of several PE surface systems (pure and defected). The goal is to determine under what kind of conditions the expected Schottky energy barrier matches the current lower bound estimated by the experiments cited above.

Our DFT modelling has suggested that SE is highly unlikely to occur if the surface is neutral. Density of states analysis has revealed that the SE is also related to chemical defects. The latter must exhibit electronic states slightly under the conduction band. Furthermore, these sites must be able to act as a trap for negative charge excess. A negatively charged PE system, combined with specific oxidative groups, has proved to be consistent with experimental data.

**Keywords :** *Electronic structure, Defected Polyethylene, Schottky Effect, DFT simulations*

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**OP-VA02**

**Lead titanate ferroelectric thin films prepared by polymeric precursor method**

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The structural characterization and ferroelectric properties of lead titanate (PbTiO<sub>3</sub>) thin films successfully deposited on SiO<sub>2</sub>/Si(100) and LaNiO<sub>3</sub>(110)/SiO<sub>2</sub>/Si(100) substrates using the sol-gel spin coating process have been studied. XRD patterns showed that the thin films have the perovskite phase. The ferroelectric character was confirmed by the P-V loops that recorded on this film with a remanent polarization and coercive field in the order to those reported for other similar systems, the measured current-voltage characteristics were found to be space charge conduction in the high applied voltage and its piezoelectric coefficient  $d_{33}$  was measured by a Laser Scanning Doppler Vibrometer.

**Keywords:** *Lead titanate thin film, Structural characterization, Ferroelectric properties*

**OP-VA03**

**Electric modulus spectroscopic studies of the dielectric properties in  
reduced Graphene Oxide loaded epoxy polymer composites**

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Dielectric properties of reduced Graphene Oxide (rGO) mixed into epoxy resin, Diglycidyl Ether of Bisphenol A (DGEBA) were studied in the frequency range  $10^2 - 10^6$  Hz and over the temperature range of 300 - 400 K, using impedance spectroscopy. For this study, a series of samples were prepared with various filler contents. Using the electric modulus formalism, it has been found that these composites exhibit, below and above the percolation threshold  $\phi_c$  a dielectric relaxation phenomenon due to the  $\alpha$  - relaxation, which is associated to the glass-rubbery transition of the epoxy matrix above the glass transition temperature. The Cole-Cole model of dielectric relaxation was used for modeling the relaxation processes from which we extract the relaxation parameters. The obtained relaxation parameters suggest a behavior close to single relaxation time. Furthermore, the relaxation time as a function of temperature is characterized by an Arrhenius behavior

**Keys words:** Composite materials, dielectric properties, relaxation phenomenon, percolation threshold.



**OP-VA04**

**Dielectric Resonator with a Novel Antenna geometry fed by a  
microstrip line for 5G applications.**

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The present work exhibits a Dielectric Resonator with a Novel Antenna geometry (DRNA) operating at Ka-band for 5<sup>th</sup> generation (5G) wireless communications. The used dielectric resonator is considered a new candidate in the field of antennas because of its good radiating power factor. The DRNA is made up of a FR4 Epoxy substrate material with relative permittivity of 4.4 and height of 1.8 mm in which we added a dielectric resonator with a relative permittivity of 8.3, height of 1.5 mm and radius of 1.34 mm and fed by a single microstrip line feed. The simulations have been carried out with two Softwares, providing that the antenna is radiating at a frequency of 28 GHz with a return loss value less than 10 dB and good radiation pattern, gain, directivity, and large bandwidth. The obtained results showed that this antenna can be applied in many wireless satellite applications.

**Keywords:** *Cylindrical Dielectric Resonator Antenna (CDRA), Gain, Return Loss, Directivity, Resonant frequency, 5G.*

**OP-VA05**

**Dielectric spectroscopy of melt-extruded polypropylene carbon nanofiber composites**

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The influence of carbon nanofibers (CNFs) weight contents, from 0 to 3 wt. %, on the structural, morphological, and dielectric properties of melt-extruded polypropylene carbon nanofiber composites is discussed in this study. The morphologic analysis reveals that the CNFs exhibited randomly distributed agglomerates in the polypropylene (PP), whereas the structural analysis demonstrates that the CNF degree of disorder was not altered in the PP/CNF composites. The AC conductivity and dielectric permittivity behavior of the PP/CNF composites are discussed and associated with the inter-cluster polarization effects between the CNF agglomerates from the analysis of percolation power laws at a certain weight content of CNFs. Finally, the complex impedance and Nyquist plots of the PP/CNF composites are analyzed by using equivalent circuit models, consisting of a constant phase element. The analysis gathered in here intends to contribute to the dielectric properties understanding of polypropylene composites filled with carbon nanofibers.

**Keywords:** *Polymer composites, Carbon nanofiber, Polypropylene, Dielectric properties, Impedance spectroscopy.*

**Acknowledgments:** A. J. Paleo acknowledges support from FCT-Foundation for Science and Technology by the “plurianual” 2020-2023 project UIDB/00264/2020, and the TSSiPRO-NORTE-01-0145-FEDER-000015 funded by the regional operational program NORTE 2020, under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund.

**OP-VA06**

**Low temperature synthesis and characterization of barium stannate titanate powders**

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BaTi<sub>0.89</sub>Sn<sub>0.11</sub>O<sub>3</sub> is one of the reported systems that exhibits high dielectric properties and enhanced energy storage parameters. In this work, lead free barium stannate titanate was elaborated for the first time via a chimie douce method at low temperature. A pure and uniform ferroelectric powder was obtained at 180°C using sol-gel and hydrothermal combined. The effect of the barium precursor on the purity and the crystallinity of the powder was also studied. X-ray diffraction (XRD) and scanning electron microscopy (SEM) were used for the characterization of the fine obtained materials. This eco-friendly and pure powder can be used without any further heat-treatment in several applications such as nano-generators for energy harvesting, capacitors and sensors.

**Key words:** *Lead free BTSn (BaTi<sub>0.89</sub>Sn<sub>0.11</sub>O<sub>3</sub>), sol-gel, hydrothermal, characterization.*

**OP-VA07**

**New two-dimensional functionalized silicon dispersible nanosheets  
prepared by direct exfoliation of calcium disilicide**

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Among the variety of two-dimensional (2D) materials, Silicon Nanosheets (SiNSs) having nanometers thicknesses and lateral dimensions ranging from the submicrometer to the micrometer scale are expected to open new perspectives of applications<sup>1,2</sup> such as energy storage, bio and nanomedicine, biosensors and coating. Since a decade, the functionalization of SiNSs has been explored by difficult multistep reactions with calcium disilicide (CaSi<sub>2</sub>) as precursor<sup>3</sup>. However, the chemical functionalization of such layered materials suffers some disadvantages and needs to be improved. Herein, we describe a new route involving the direct functionalization of CaSi<sub>2</sub> with organic compounds such as benzyl halides and tosyl chloride by heat in a sand bath. The preservation of the crystalline silicon structure was confirmed by X-ray diffraction while the coverage of the organic compounds onto the materials was evident by infrared and thermogravimetric analyses. The morphology of the synthesized nanosheets was investigated by electronic and atomic force microscopy, in which the plate-like structures are seen in several nanometer scales with thicknesses between 2 to 4 nm. Moreover, the dielectric study with temperature dependency showed high dielectric permittivities, without any conducting polymer, induced by different phenomena occurring onto the layered nanosheets. These encouraging results prove that specific applications such as electrochemical detection, antibacterial activities, photovoltaic, photocatalytic and energy storage can be targeted by designing the functionalization onto nanostructured SiNSs.

**Keywords:** *2D materials; calcium disilicide; exfoliation; functionalization; Dielectric.*

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**OP-VA08**

**Investigation of Aloe Vera Latex used as Natural Dye in TiO<sub>2</sub> based Heterojunction and Liquid-Electrolyte Dye Sensitized Solar Cells**

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The use of extracted natural compounds as dye sensitizers is a promising option for the fabrication of low-cost solar cells. The latter devices transform solar energy directly into electricity. In the present study, Aloe Latex Solid (ALS), that is a yellow orange solid compound extracted from the Aloe Vera leaves, was deposited on a TiO<sub>2</sub> thin film (TiO<sub>2</sub>/ALS) for the construction of two different configurations of solar cells. The UHPLC-DAD-ESI-MS analysis, UV-Vis and FTIR spectroscopic studies were performed for the prepared dye sensitizer. In fact, the performance of the TiO<sub>2</sub>/ALS composite was investigated in a heterojunction dye sensitized solar cell (HJ-DSSC) and a liquid electrolyte-based dye sensitized solar cell (LE-DSSC) to identify the architecture with highest efficiency of sunlight conversion. The obtained results showed encouraging photovoltaic performances with an open circuit voltage ( $V_{oc}$ ) varying from 0.13 up to 0.30 V, and fill factors (FF) less than 40%. Interesting solar conversion efficiencies were obtained for both architectures with a maximum value of about 1.17% corresponding to the LE-DSSC configuration.

**Keywords:** *Natural dye, TiO<sub>2</sub>, Solar cells, Aloe Vera Latex, Current-Voltage (I-V).*

## **OP-VA09**

### **From red phosphorus to 2D phosphorene: synthesis and characterization**

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Black phosphorus (BP) is the most promising material among the two-dimensional (2D) materials thanks to its layered structure and excellent semiconducting properties. Currently, bulk BP flakes are synthesized under high pressure and high-temperature conditions by chemical vapor deposition using high-cost Au-catalyst. Consequently, its applications as a crystalline semiconductor material in electronic devices are limited due to the low quality and purity of BP. In this work, we demonstrate an efficient and low-cost synthesis of highly crystalline BP by rapid low-pressure reaction of red phosphorus (RP) in the presence of a small amount of silver (Ag) in a vacuum-sealed quartz tube. The phosphorene layers were prepared by liquid-phase exfoliation (LPE) of high-quality BP crystals using various solvents such as isopropanol (IPA), N-methyl pyrrolidone (NMP) and Dimethylformamide (DMF). The resulting materials are investigated in detail including structural and morphological characterization along with thermal properties. We have obtained BP flakes which are uniform in size and morphology. The lateral sizes of the stable BP range from 50.7 nm after exfoliation in IPA to 204 nm after exfoliation in NMP. The most effective phosphorene layer separation was achieved by using the IPA solvent and centrifugation at 15000 rpm with a monolayer thickness of 0.5 - 0.6 nm. Phosphorene layer thicknesses of 1.0 - 2.0 nm and 1.7 - 2.6 nm are obtained when using NMP and DMF as solvents, respectively. We demonstrate the fine tuning of the optical bandgap by controlling the number of phosphorene layers.

**Keywords:** *black phosphorus, low-pressure synthesis, liquid phase exfoliation, phosphorene layers, structural and morphological characterization.*

**OP-VA10**

**Giant electrocaloric effect and high energy storage efficiency in lead free  
BCTSn ceramic elaborated by sol gel method**

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The current work deals with the study of structural, dielectric, ferroelectric, energy storage and electrocaloric effect in lead free ceramic BCTSn elaborated by sol gel method. Phase purity structure was confirmed from X-ray data by using Rietveld refinement, and revealing the co-existence of tetragonal (P4mm) and orthorhombic (Amm2) symmetries at room temperature. Phase transitions were pointed out by dielectric and differential scanning calorimetry results. Energy storage properties were determined from P-E hysteresis. Moreover, the electrocaloric effect properties were calculated indirectly via Maxwell approach, and a giant value of  $\Delta T=0.807$  K is obtained under  $30 \text{ kV cm}^{-1}$ . All obtained results make BCTSn ceramics a promising candidate for environmentally friendly refrigeration and energy storage applications.

**Keywords :** *BCTSn, sol-gel, structural properties, dielectric properties, Electrocaloric, ferroelectricity, Energy storage, phase transition temperature.*



**Oral Presentations**  
**(Session VB)**

**OP-VB01**

**Effect of an additive organic A1 in improving the quality of nickel electroplating on brass**

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Nickel plating on brass is a technique widely used in various industrial activities. The different deposition processes are relatively complex; depend on several factors such as PH, temperature, and bath composition. Nickel plating in watt baths is frequently used in large surface treatment industries due to the appearance and stability of the deposit over time. To improve the quality of nickel deposition on brass, a comparison of nickel plating by the Watts bath with an electrolytic nickel bath mixed with an organic additive, A1 was carried out. Monitoring and characterization of the deposits were carried out by scanning electron microscope (SEM) and X-ray diffraction; the results obtained show the appearance of cracks and micro-grains on the surface of the nickel deposit made in the Watts bath. On the other hand, the proposed bath gives a better quality of the deposit, the addition of the organic adjuvant A1 allows the homogeneity and brightness of the nickel deposit to be maintained.

**Keywords:** *Brass, Nickel plating, Surface treatment, SEM.*

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**OP-VB02**

**Synergistic formulation from *Allium Sativum* essential oil and diethyl thiourea for corrosion inhibition of carbon steel in 0.5 M H<sub>2</sub>SO<sub>4</sub> medium.**

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Carbon steel is one of the most important alloys used in many industries. This type of metal is susceptible to corrosion when in contact with aggressive environmental conditions. Acidic solutions are widely used in industrial acid cleaning, acid descaling and oil well acidification, all of which aggravate steel corrosion. Corrosion inhibition using active substances whose molecular structure admits active adsorption sites with solitary pair and/or  $\pi$  orbitals, such as heterocycles containing sulfur, oxygen, phosphorus, and/or nitrogen atoms, is the least expensive and most effective method of protection. These compounds can form either a strong coordination bond with a metal atom or a passive film on the surface.

Essential oils and plant extracts are extremely rich sources of organic molecules that can act as corrosion inhibitors. This is proven by corrosionists who have started studies on the application of these natural substances.

The objective of our study is to evaluate the synergistic effect of *allium sativum* essential oil and diethylthiourea to inhibit corrosion of carbon steel against 0.5M sulfuric acid medium, after extraction and identification of the essential oil by gas chromatography-mass spectrometry (GC-MS), an electrochemical study was performed by different electrochemical techniques (impedance spectroscopy (EIS), potentiodynamic polarization, and surface analysis by scanning electron microscopy (SEM)). The polarization curves indicate that the mixture used acts as an excellent inhibitor slowing down the corrosion rate. An appropriate electrical equivalent circuit model was used to calculate the impedance parameters, the results obtained showed that the inhibitory efficiency depends on the concentration of the compound as well as the temperature used. It reached 99% at a concentration of 1.5 g/l, also other thermodynamic parameters of the activation process and metal dissolution as well as SEM results were calculated and discussed.

**Keywords:** *Corrosion; Carbonsteel; Allium Sativum ; H<sub>2</sub>SO<sub>4</sub>;Inhibitor.*

**OP-VB03**

**The anti-corrosive property of apatite tricalcium phosphate on carbon steel  
in two acid media HCl 1M and H<sub>2</sub>SO<sub>4</sub> 0.5 M.**

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The deterioration of materials under the influence of the surrounding environment causes serious damage up to the destruction of the metal. In order to solve this problem, several protection methods have been considered, among which are corrosion inhibitors.

Apatitic calcium phosphates are biomaterials with attractive physicochemical properties, they have been used for years in the medical field, which makes them a center of interest for researchers to use as corrosion inhibitors of materials. The objective of our study is to evaluate the inhibitory action of apatitic tricalcium phosphate of formula Ca<sub>9</sub>(HPO<sub>4</sub>)(PO<sub>4</sub>)<sub>5</sub>(OH) on the corrosion of carbon steel in two aggressive media H<sub>2</sub>SO<sub>4</sub> 0.5M and HCl 1M. PTCa was synthesized by the double decomposition method in aqueous medium, it was characterized by chemical analysis (CA), Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction (XRD). Then, it was evaluated as an inhibitor for carbon steel using different electrochemical techniques, electrochemical impedance spectroscopy (EIS) and stationary polarizations (PDP). Thus, an analysis of aggressive solution before and after addition of PTCa was carried out by visible UV. The results obtained show that the inhibitory efficiency of PTCa in 1M HCl reaches 93% at a concentration of 50 ppm and 95% at a concentration of 200 ppm in 0.5M H<sub>2</sub>SO<sub>4</sub>.

**Keywords:** carbon steel, Apatitic tricalcium phosphate, inhibitor, acid media, Corrosion.

**OP-VB04**

**Molecular simulations of dielectric and spectroscopic properties of 4-Cyano-4'-pentylbiphenyl liquid crystal and their comparison with experimental findings**

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The liquid crystalline materials exhibit a certain degree of orientational and positional order parameters along with the fluidity due to the presence of alkyl chain in the structure. This combination of parameters makes them suitable that lead to a plenty of fundamental and technical applications. In this investigation, the structural, dielectric and other physical properties of a well-known liquid crystal (LC) material namely 4-Cyano-4'-pentylbiphenyl (5CB) have been theoretically investigated via density functional theory (DFT) by using the Gaussian 09 and Quantum ESPRESSO tools and a comparison has been done with the experimental findings. The dielectric properties were successfully simulated in THz region using DFT theory along with experimental investigation in the 100 Hz- 1 MHz region. The dielectric results have been found to be in good agreement with the previous findings. This study certainly provides further insight to investigate anisotropic material theoretically as well as experimentally in order to use it for low and high-frequency applications.

***Keywords:*** *Density functional theory, 5CB liquid crystal*

**OP-VB05**

**Synthesis, dielectric, Raman and IR spectroscopic studies of BiScO<sub>3</sub> phase samples with a perovskite-type structure**

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The metastable BiScO<sub>3</sub> phase with a perovskite-type structure was obtained by thermobaric synthesis. Phase formation has been studied in a Bi<sub>2</sub>O<sub>3</sub>-Sc<sub>2</sub>O<sub>3</sub> mixture fired at 800°C and subjected to thermobaric treatment at T = 800 - 1200°C, p = 6 - 7.5 GPa. It was found that the BiScO<sub>3</sub> phase with a perovskite-type structure is formed at T = 1000 - 1200°C, p = 6 - 7.5 GPa, the region of its stable existence at atmospheric pressure lies at T < 700°C. Single-phase samples synthesized at 1200°C and 7 GPa were investigated by FTIR spectroscopy in the temperature range of 5-450 K and by micro-Raman and dielectric measurements at T=80-700K.

As in the case of the related compound BiMnO<sub>3</sub>, the bismuth scandate is considered in the context of the issue of its centrosymmetric monoclinic crystal structure, and specifically concerns the two space groups C<sub>2</sub> and C<sub>2/c</sub> [1]. The factor group analysis assumes 57 IR and Raman active modes in the case of a noncentrosymmetric group C<sub>2</sub>, while for a centrosymmetric group C<sub>2/c</sub> the alternative prohibition rule is fulfilled - modes are active either in the IR spectra (27 modes) or only in the Raman spectra (30 modes) [2]. At 5 to 400 K, 48 modes were observed in the IR spectra, that is significantly larger than 27 predicted as by factor group analysis for the noncentrosymmetric space group C<sub>2</sub>, while 24-26 modes appearing in the Raman spectra at T=80-400 K are more likely to correspond to the centrosymmetric group C<sub>2/c</sub>. However, the weak contribution of additional lines to the IR and Raman spectra rather indicates a centrosymmetric structure with breaking the selection rules, which can be caused by disorder in the crystal structure or strong local polar distortions induced by the Bi<sup>3+</sup> lone pairs. An anomalous behavior of the spectral response is observed when approaching 400 K. Many weak IR and Raman active phonons disappear, and the intensity of the Raman spectra begins to decrease, probably due to an increase of conductivity. Arguments in favor of several reasons for this behavior are analyzed: a) the presence of a structural phase transition or b) strong lattice anharmonicity and a large dynamic disorder of Bi cations. The pronounced anomalous changes in the temperature dependences of the dielectric constant ε(T) and the dielectric loss tangent tgδ(T) studied in the temperature range T = 10 - 350 K at frequencies f = 25 Hz - 1 MHz, not found. An increase in temperature causes a monotonic increase in the values of ε and tgδ.

The research was supported by the RFBR (Part of the works on the thermobaric synthesis of samples and the study of its dielectric properties in the low-frequency range) (project № 20-02-00915). V.G.T acknowledges RSF 2021(FTIR and Raman measurements) (project № 21-12-00358)

**Keywords:** *BiScO<sub>3</sub>, Raman, FTIR-spectra, dielectric properties*

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**OP-VB06**

**Local symmetry breaking and formation of low-symmetry phase in  
 $\text{Sr}_{0.97}\text{Ba}_{0.03}\text{TiO}_3$  ceramic and thin film studied by vibrational spectroscopy**

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Quantum paraelectrics attract the attention of researchers due to both their applied and fundamental significance. The possibility of indicating polar and magnetic phases by creating defects, by cationic substitution and by mechanical stress, allows one to speak about the prospects of their use in various reconfigurable devices, sensors and memory elements. From a fundamental point of view, interest in quantum paraelectrics is caused by the specific features of phase dynamics, mechanisms of phase transitions, and exotic ground states. The aim of this study is to establish the effect of dipolar orderings on the oscillator parameters of lattice excitations and to reveal the role of various mechanisms and interactions in the formation of the phases in the vicinity of multiphase critical point  $T=48$  K,  $x=0.029$  on the phase diagram of  $\text{Ba}_x\text{Sr}_{1-x}\text{TiO}_3$  predicted by the phenomenological theory [1].

A thin (~ 100 nm) film of the  $\text{Sr}_{0.97}\text{Ba}_{0.03}\text{TiO}_3$  solid solution was prepared by pulsed laser deposition on a MgO substrate. The ceramic sample used as a target was obtained by the solid-phase reaction method. Both samples were studied using X-ray diffraction, Fourier-transform infrared (FTIR), terahertz and Raman spectroscopy techniques. We discover differences in the temperature behavior of the spectral response of the thin film in comparison with the bulk ceramic sample, and a clear presence of a lower-symmetry phase. The spectral signature of the low-symmetry phase increases dramatically during cooling. In the Raman spectra of the thin film, IR-active lines are observed that are forbidden by the selection rules, indicating a local symmetry breaking and the appearance of polar nanoclusters at  $T = 150$  K. These changes in the Raman response are accompanied by a shift of the ferroelectric soft mode towards low frequencies and by the appearance of additional absorption lines below  $T = 120$  K in the IR spectra. A significant transformation of the spectral response with decreasing temperature is associated with the percolation of polar nanoclusters during the formation of low-symmetry phase [2]. However, the emergence at high frequencies, above  $1000\text{ cm}^{-1}$ , of additional absorption lines in the Raman spectra cannot be explained by two-phonon processes and is probably a consequence of a more complex interaction of phonons at the boundaries of the Brillouin zone. Arguments in favor of the formation of phases predicted by the phenomenological theory [1] are discussed.

The research was supported by the RFBR (bulk sample synthesis, spectroscopic measurements of thin film and X-ray characterization of samples) (project № 17-02-01247) and MECOP (thin film synthesis). V.G.T and E.S.Z acknowledges RSF 2021(data analysis, spectroscopic measurements and chemical analysis of the bulk ceramic) (project № 21-12-00358)

**Keywords:** *phase transitions, perovskite, polar nanoclusters*

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**Oral Presentations**  
**(Session VC)**

**OP-VC01**

**AC conductivity and dielectric response of carbon dots/PMMA  
nanocomposite materials**

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The AC electrical conductivity and dielectric properties of an original nanocomposite based on the incorporation of carbon dots (C-dots) in poly (methyl methacrylate) (PMMA) at several filler loadings were studied in the frequency range from 100 Hz to 100 kHz, in the temperature range from 200 to 380 K. We provide experimental evidence that at low frequencies the dielectric response without peak loss  $\varepsilon''_{max}$  is anomalous low-frequency dispersion. Also, below percolation threshold [1], and at high frequencies, the curves of  $\varepsilon'$  and  $\varepsilon''$  are parallel, suggesting that the presence of the fillers greatly affect the dielectric properties of the polymer matrix because of polarization phenomenon induced by the C-dots nanoparticles. This theoretical framework is consistent with several aspects of the experiments, notably the power-law decays of the real and imaginary parts of the complex permittivity which is characterized by the fractional exponents'  $n$ . The obtained exponents are positive and smaller than unity, with a value close to 1. These values of  $n$  are decreasing with increasing of the temperature and filler loading. We found that the activation energy is insensitive to the presence of the C-dots nanoparticles, thus revealing the weak interaction between the nanofillers and the chain segments of the macromolecules in the copolymer [2].

**Keywords :** AC conductivity, Dielectric response, C. dots, nanocomposites

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**OP-VC02**

**Effects of Additive in an Electrodeposition Bath on the Surface  
Morphologic Evolution of Electrodeposited Copper**

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In this work, copper electroplating has been frequently used to improve the quality of copper deposition (brightness, hardness, adhesion...). The effect of an organic additive AN under various concentrations on electrodeposited copper was studied. Correctly concentrations of the organic additive AN added in the electrodeposition bath made the adsorbed additive partly converge and optimized the quality of the copper plating. In addition, the morphology of the copper deposits obtained in the absence and presence of organic compounds has been studied by scanning electron microscopy (SEM). An improvement of the roughness degree and crystallite size upon the addition of AN has been found. The best results were obtained for AN working at room temperature ( $25 \pm 0.1^\circ\text{C}$ ) and  $1 \text{ Adm}^{-2}$  current density.

**Keywords:** *Copper; Electroplating; Cyclic voltammetry; Current density; SEM.*

### **OP-VC03**

#### **Electrical, and dielectric properties of Yttrium-doped BaTiO<sub>3</sub> ceramics.**

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The main purpose of the present work is to investigate the dielectric properties of BT and Ba<sub>0.98</sub>Y<sub>0.02</sub>Ti<sub>0.995</sub>O<sub>3</sub> ceramic prepared via solid-state reaction under a sintering temperature of 1250 °C which is the lowest temperature as compared to the literature. To our understanding, there is a scarcity of information on Ba<sub>0.98</sub>Y<sub>0.02</sub>Ti<sub>0.995</sub>O<sub>3</sub> electrical and dielectric studies. For these reasons, phase structure characterization, scanning electron microscopy, FTIR, and Raman spectroscopy were investigated. Then, the dielectric was evaluated using the temperature dependence of the dielectric permittivity and loss tangent (tanδ). Also, the conductivity of ceramics was discussed by applying the Arrhenius equation. The frequency dependence of impedance and electric modulus properties were studied over a wide frequency range at various temperatures. The tetragonality of these structures was identified by using powder X-ray diffraction and Raman analysis. Structurally, BaTiO<sub>3</sub> has a uniform grain size, but Ba<sub>0.98</sub>Y<sub>0.02</sub>Ti<sub>0.995</sub>O<sub>3</sub> sample consists of a different shape and size with homogeneous morphology and dense microstructure, as observed by scanning electron microscopy. Through dielectric measurements, the Y-doped BT ceramic had a higher Curie temperature (T<sub>C</sub>) and dielectric constant at T<sub>C</sub> (125°C and 6071) compared to the pure BaTiO<sub>3</sub> ceramic (110°C and 4156) when measured at 100 kHz [1], [2]. The modeling dielectric constant confirmed the presence of first-order and displacive transitions for both samples, but the diffusive behavior took place in the doped sample. It was also confirmed, regarding conductivity, that introducing Yttrium into the BaTiO<sub>3</sub> structure is a viable way to reduce the number of oxygen vacancies. Furthermore, Complex impedance Cole-Cole showed the relaxation behavior in the Ba<sub>0.98</sub>Y<sub>0.02</sub>Ti<sub>0.995</sub>O<sub>3</sub> materials to be of non-Debye type.

These works motivate to produce a dense Ba<sub>0.98</sub>Y<sub>0.02</sub>Ti<sub>0.995</sub>O<sub>3</sub> ceramic with fewer defects, and a low concentration of oxygen vacancies.

**Keywords:** *Perovskite, Structural, Dielectric, Conductivity, Impedance spectroscopy*

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**OP-VC04**

**The improvement of mechanical properties of lead acid battery grids  
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Research works on lead alloys are experiencing an increasing growth both for the fundamental study of their structural properties and for their numerous applications in the automotive industry. Indeed, for ecological and economic reasons, much research has been carried out in order to increase the performance of the lead-acid battery for its use as an energy source in electric cars. The challenge is therefore to select an alloy with good corrosion resistance and improved mechanical properties. The use of lead alone is excluded because this metal is soft and malleable, thus lacking hardness and strength. But the dissolution of a few solutes in the liquid lead solvent allows the supersaturation of the primary solid phase and thus makes it possible to obtain cured alloys for the manufacture of plate's accumulator [1, 2]. Our aim is to select lead alloys with a good corrosion resistance and improved mechanical properties based on aging and over aging process of supersaturated quenched solutions. Indeed, two structural states are considered: as-cast alloy and rehomogenized. The influence of temperature has been studied. The techniques used are: hardness, micro-hardness, optical microscope, X-ray diffraction and scanning electron microscope.

**Keywords:** *Alloy, battery grids, Lead, hardness, aging.*

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## **OP-VC05**

### **The mechanism study of the breakdown process of air near the flashover discharge**

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The phenomenon of flashover observed on the insulators of the airlines of the high voltage polluted is the result of a process, which proceeds in successive stages well defined. The origin of this phenomenon is related to the covering of the surface of the insulators of a layer of conducting pollution. This layer is not deposited in a uniform way, its distribution along the creepage distance present of fluctuating dimensions. The majority of the equipment of the high voltage are installed in the open air in atmospheres aggressive and polluted such as the zones tropical, Arctic, littoral. Each one of these areas is characterized by a climate and a specific pollution. For this reason, the pollution of the insulators associated with the presence with moisture decreases the level of insulation of the system. Indeed the contribution of water on the level of the deposit of pollution causes the dissolution of salts and conduit to the formation of an electrolytic layer. A leakage current, circulates then in the surface layer by causing a local draining of the electrolyte, which causes to increase the conductivity of the medium. Surface discharges appear on surface, which under favorable conditions lengthen along the insulator and connect the high voltage to the mass, this phenomenon is called flashover [1-3]. This work concerns the study of the electric vicinity of the air under the influence of certain parameters: resistivity, polarity, initial current of the discharge as well as the electric field. We made an experimental study on the rupture of the air in an interval between a discharge and an electrolytic surface of which the goal to clear up the mechanism of evolution of the discharge of skirting. The experimental results of this handling are exceptional from the point of view influences local discharge (trigger) on the effect of the polarity of the breaking stress of the principal interval [4-6].

**Keywords:** *Discharge, Flashover, Insulator, Pollution, High voltage*

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**OP-VC06**

**Composite multiferroics with phosphate ceramic as a matrix**

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The phosphate bonded ceramics (PBCs) is the intermediate step between the inorganic and polymer materials. An important advantage of PBCs is the simplicity and low cost of the preparation procedure, phosphates are safe and eco-friendly. The preparation and curing steps are possible at room temperature or with slight heating, no sintering is required. The absence of the sintering step allows to load the samples with additional fillers and avoid interactions between them, such as reactions between ferroelectrics and ferromagnetic phases in composite multiferroics or evaporation of lead from lead-based ferroelectrics.

Here we report on the study of the composite materials based on the phosphate matrices with ferroelectric inclusions ( $\text{Pb}(\text{Mn}_{1/3}\text{Nb}_{2/3})\text{O}_3 - \text{PbTiO}_3$ ) and a mixture of ferroelectrics ( $\text{BaTiO}_3$ ) and ferromagnetics ( $\text{Fe}_3\text{O}_4$ ). Several significant advantages of the utilization of phosphates were found. In comparison with the polymer-based or cement-based composites, the usage of phosphate matrices allows to successfully synthesize of composite material with substantially high (83 wt. %) content of ferroelectrics. In contrast to the presented in literature methods of the multiferroic material synthesis, the phosphate-based ceramics benefits the simplicity of the preparation. In comparison with polymer-based composites, the inorganic matrix provides advanced thermal stability and mechanical contacts between different phases.

The dielectric, ferroelectric, magnetic and piezoelectric properties of the prepared samples were studied in wide temperature ranges. The dependence of the density of the ceramic on the applied pressure was investigated. The XRD analysis indicates the absence of any side-products obtained upon the synthesis procedure. The characteristics of the composites are stable in the temperature range up to 900 K.

The presented methods of the preparation of the matrix-based composites filled with ferroelectric, ferromagnetic particles and their mixture are promising for the variety of applications. In particular, the composites with ferroelectric nanoparticles are perspective for the memory devices, electromechanical sensors and energy storage. The composites with ferromagnetic particles applied for electromagnetic shielding, construction materials and anti-corrosion coatings. The multiferroic composites are perspective for the range of sensing, transduction and memory applications.

**Keywords :** *Barium titanate, PMN-PT, Magnetite, Phosphates, Multiferroic, Composite.*

**Acknowledgements:** A.P. is supported by the European Social Fund under the No 09.3.3-LMT-K-712-19-0146 “Development of Competences of Scientists, other Researchers and Students through Practical Research Activities”.



## **OP-VC07**

### **Dielectric relaxation in Ba(Ti<sub>1-x</sub>Sn<sub>x</sub>)O<sub>3</sub> solid solutions**

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Barium titanate (BTO) is a first inorganic material where the ferroelectricity was discovered. Barium titanate has a perovskite structure in which ferroelectricity occurs due to the off-centering of Ti ions in oxygen octahedral cage. The material undergoes three consecutive phase transitions [1]. The high temperature phase is paraelectric which transforms to the tetragonal, orthorhombic and rhombohedral ferroelectric phases when the temperature decreases.

Barium titanate can be considered as multifunctional materials for different applications. The largest application area of BTO is multilayered ceramic capacitors due to its large weakly temperature dependant permittivity in the vicinity of room temperature. Unfortunately, the loss and energy storage density of such capacitors are strongly dependent on the domain structure of the ferroelectric phase of BTO. In order to maximize the energy storage density and decrease the loss which arises due to domain wall motion, it is necessary to modify BTO to pin the domains or reduce their density.

Isovalent substitutions such as Ce<sup>4+</sup>, Zr<sup>4+</sup>, Hf<sup>4+</sup> or Sn<sup>4+</sup> instead of titanium ion modifies the phase transitions of barium titanate. Some of these ions can be substituted throughout all the concentration range. The material undergoes crossover from ferroelectric properties to a relaxor properties.

In this contribution we will focus on the Sn<sup>4+</sup> substituted barium titanate (BaTi<sub>1-x</sub>Sn<sub>x</sub>O<sub>3</sub>) in the crossover region (i. e.  $0.15 \leq x \leq 0.3$ ) between ferroelectric and relaxor behavior. The dynamics of the crossover will be studied by broadband dielectric spectroscopy methods from milihertz to terahertz range. Also, the NMR studies of tin ions will be presented. Such experimental technique will provide some insights about different displacements of a titanium ions surrounding tin.

**Keywords:** *relaxors, perovskite oxides, barium titanate, broadband dielectric spectroscopy*

#### **Acknowledgement**

This project has received funding from European Social Fund (project No 09.3.3-LMT-K-712-19-0052) under grant agreement with the Research Council of Lithuania (LMTLT).

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**OP-VC08**

**Dielectric properties of new lead-free oxide materials ceramics on the base  
of KNN and NBT perovskites**

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Lead-free perovskite oxides based on ferroelectrics ( $K_{0.5}Na_{0.5}NbO_3$  (KNN),  $BaTiO_3$  (BT), and ferroelectric-relaxor ( $Na_{0.5}Bi_{0.5}TiO_3$  (NBT) are being intensively studied in order to replace widely used toxic Pb-based ones. These oxides are promising for applications in capacitors, piezoelectrics, electrocaloric and other devices. We studied influence of donor and acceptor dopants on structure, microstructure, and dielectric properties of compositions from Morphotropic Phase Boundary (MPB) in the KNN-BT and NBT-BT systems additionally modified with overstoichiometric additives KCl, NaCl, LiF, ZnO и CuO. Ceramic samples were prepared by the two-step solid-state reaction method and were characterized using complex of physico-chemical methods: X-ray Diffraction, Scanning Electron Microscopy, Second Harmonic Generation, and Dielectric Spectroscopy. Unit cell parameters changes were observed in modified compositions depending on radii of substituting cations. Ferroelectric phase transitions at 400 – 700 K were observed. Phase transitions near ~ 400 K in NBT-based compositions revealed typical relaxor behavior related to the presence of polar nanoregions in a nonpolar matrix. Additionally, effects of dielectric relaxation caused by formation of oxygen vacancies due to possible deficiency in the A-sites and/or by the presence of cations with mixed valency in the B-sites of perovskite lattice were observed at temperatures > 700 K. The compositions characterized by increased values of dielectric permittivity at the room temperature and spontaneous polarization were revealed confirming prospect of their functional properties improvement.

**Keywords:** *Perovskite structure, Dielectric materials, Ferroelectrics.*

**Funding:** The work was supported by the RFBR and DFG (Project 21-53-12005).

**Biography :**

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**OP-VC09**

**Thermal and Spectral Dielectric Properties of  
Polypyrrole/Polymethylmethacrylate Composites**

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Thermal properties of polypyrrole/polymethylmethacrylate (PPy/PMMA) composites were analyzed by thermal gravimetric analysis (TGA) and differential scanning calorimetry (DSC). A decrease in the glass transition temperatures with PPy concentration reveals the increase of segmental motion. The dielectric properties of these composites were studied for several weight concentrations of PPy in the frequency range between 500 Hz and 0.2 MHz, over the temperature range 23–110°C. Jonscher's phenomenological model has been used for modeling the dielectric response of the composite materials. This study shows that the results obtained for the dielectric response are in good agreement with the results of TGA and DSC measurements.

**Keywords:** *Thermal properties, Composite materials, Thermal Gravimetric Analysis, Differential Scanning Calorimetry, dielectric properties.*

# **Poster Presentations**

## **(Session V)**

**PP-V01**

**Synthesis, structure, dielectric, and energy storage properties of  
Ba<sub>0.85</sub>Ca<sub>0.15</sub>Zr<sub>0.1</sub>Ti<sub>0.9</sub>O<sub>3</sub> ceramics under large electric field**

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Lead-free Ba<sub>0.85</sub>Ca<sub>0.15</sub>Zr<sub>0.1</sub>Ti<sub>0.9</sub>O<sub>3</sub> (referred to as BCZT) ceramic powders were synthesized using the sol-gel method. Dielectric, ferroelectric, and energy storage properties were investigated. Indeed, pure crystalline structure and homogenous microstructure are identified by XRD analysis and SEM measurement.

The dielectric measurements in a frequency range of [100Hz-1MHz] and a temperature range [20-200°C] reveal a maximum dielectric constant which is associated with ferroelectric-paraelectric phase transition[1]. The dielectric constant  $\epsilon_r$  at 1kHz was 18177 around 78°C which indicates that the sol-gel method has displayed important electrical properties.

The P-E loop shows a closed and saturated loop similar to a conventional ferroelectric [2]. The maximal polarization ( $P_{max}$ ), the remnant polarization ( $P_r$ ), the charge storage density ( $Q_c = P_{max} - P_r$ ) and the coercive field ( $E_c$ ) were found to be 25,59  $\mu\text{C}/\text{cm}^2$ , 15,19  $\mu\text{C}/\text{cm}^2$ , 10,4  $\mu\text{C}/\text{cm}^2$ , and 6 kV/cm, respectively. Besides, BCZT showed better recoverable energy density  $W_{rec}$  of 0.23 J/cm<sup>3</sup> with an efficiency coefficient of ~ 88% at 150 °C under an electric field of 55 kV/cm. These results suggest that the synthesized BCZT ceramic could be a promising candidate for energy storage applications [3].

**Keywords:** BCZT ceramics; sol-gel method; dielectric; energy storage.

**References**

[1] J. P. B. Silva *et al.*, « Ferroelectric phase transitions studies in 0.5Ba(Zr<sub>0.2</sub>Ti<sub>0.8</sub>)O<sub>3</sub>-0.5(Ba<sub>0.7</sub>Ca<sub>0.3</sub>)TiO<sub>3</sub> ceramics », *J. Electroceramics*, vol. 35, n° 1, p. 135-140,( déc. 2015).

[2] H. Mezzourh *et al.*, « Enhancing the dielectric, electrocaloric and energy storage properties of lead-free Ba<sub>0.85</sub>Ca<sub>0.15</sub>Zr<sub>0.1</sub>Ti<sub>0.9</sub>O<sub>3</sub> ceramics prepared via sol-gel process », *Phys. B Condens. Matter*, vol. 603, p. 412760, (févr. 2021).

[3] S. Merselmiz *et al.*, « High energy storage efficiency and large electrocaloric effect in lead-free BaTi<sub>0.89</sub>Sn<sub>0.11</sub>O<sub>3</sub> ceramic », *Ceram. Int.*, vol. 46, n° 15, p. 23867-23876, (Oct. 2020).

**PP-V02**

**Preparation and characterization of  $\text{Cu}_2\text{Fe}_{1-x}\text{Co}_x\text{SnS}_4$  thin films via sol-gel method**

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The compound copper iron cobalt tin sulfide  $\text{Cu}_2\text{Fe}_{1-x}\text{Co}_x\text{SnS}_4$  (CFCTS) is a potential absorber thin film candidate for solar cells. In the present work, CFCTS thin film with  $x = 75\%$  was deposited on soda lime glass substrates, using sol-gel spin coating technique without a sulfurization step. X-ray diffraction, Raman spectroscopy, scanning electron microscopy, energy dispersive analysis and UV-Vis-NIR spectrometry were used to investigate the effect of annealing temperature ranging from 200 °C to 400°C in a nitrogen atmosphere for 1 hour on the structural, morphological, compositional and optical properties of the deposited thin films. The optimal annealing temperature of the pure, uniform, dense and stoichiometric CFCTS thin film is found to be 300°C. In addition, UV-Vis analysis confirms the optical band gap of 1.32 eV in the visible region which is the optimal value for converting amount of energy from solar spectrum into electricity.

**Keywords:**  $\text{Cu}_2\text{Fe}_{1-x}\text{Co}_x\text{SnS}_4$ , Sol-gel, annealing, Structural, Morphological, Electrical, Optical properties.

**PP-V03**

**A comparative study of structural, electrical, and energy storage properties in lead-free BCZT ceramics: Influence of the reduced thickness of ceramics.**

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Lead-free Ba<sub>0.85</sub>Ca<sub>0.15</sub>Zr<sub>0.1</sub>Ti<sub>0.9</sub>O<sub>3</sub> (referred to as BCZT) ceramic powders were synthesized using the sol-gel method. Dielectric, ferroelectric, and energy storage properties were investigated. In order to apply strong electric fields, the thickness of ceramics was reduced by polishing. The BCZT ceramic with 0.4 mm shows improved proprieties. Indeed, pure crystalline structure and homogenous microstructure are identified by XRD analysis and SEM measurement. The P-E loop shows a closed and saturated loop similar to a conventional ferroelectric [1]. The maximal polarization (P<sub>max</sub>), the remnant polarization (P<sub>r</sub>), the charge storage density (Q<sub>c</sub> = P<sub>max</sub> - P<sub>r</sub>) and the coercive field (E<sub>c</sub>) were found to be 25,59 μC/cm<sup>2</sup>, 15,19 μC/cm<sup>2</sup>, 10,4 μC/cm<sup>2</sup>, and 6 kV/cm, respectively. Besides, BCZT showed better recoverable energy density W<sub>rec</sub> of 0.23 J/cm<sup>3</sup> with an efficiency coefficient of ~ 88% at 423K under an electric field of 55 kV/cm. These results suggest that the synthesized BCZT ceramic could be a promising candidate for energy storage applications [2].

**Keywords** : *BCZT ceramics; sol-gel method; dielectric; energy storage*

**References :**

[1] H. Mezzourh et al., « Enhancing the dielectric, electrocaloric and energy storage properties of lead-free Ba<sub>0.85</sub>Ca<sub>0.15</sub>Zr<sub>0.1</sub>Ti<sub>0.9</sub>O<sub>3</sub> ceramics prepared via sol-gel process », Phys. B Condens. Matter, vol. 603, p. 412760, (févr. 2021).

[2] S. Merselmiz et al., « High energy storage efficiency and large electrocaloric effect in lead-free BaTi<sub>0.89</sub>Sn<sub>0.11</sub>O<sub>3</sub> ceramic », Ceram. Int., vol. 46, no 15, p. 23867-23876, (Oct. 2020).



**PP-V04**

**Influence of the Metal/Dielectric Contact on the Reliability of the  
Insulation Electrical Systems**

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The proper operation of power equipments remains the main objective each time sought, the possibilities for reaching this goal are strongly dependent on the performances of the dielectric materials used as insulation. Several, intrinsic and extrinsic, parameters like aging, operating conditions, environmental constraints...are considered as the mainly causes of performances declining of the insulation system. Recently, we have examined another parameter suspected to play a role in this problematic; it concerns an electrostatic phenomenon directly related to the designing of this kind of apparatus. In fact, the inevitable putting in contact of dielectric and metallic materials, into the power transformers, lead necessary to the formation of metal/dielectric interfaces, which certainly act on the electrical behavior of this kind of equipments. By changing the nature of the metal used, different metal/liquid and metal/paper contacts are realized and then tested with the PDC technique for different levels of the electrical stress. In this survey, thin films of dielectric samples are submitted, between two planar metallic electrodes, to DC voltages and the electrical current circulating through the dielectric is recorded with a high sensitive electrometer. Since only the metal natures of the electrodes are changed, the parameters suspected to acts on the measured current are the electrodes conductivities and/or their work function. By quantifying the involved electrical charges, these interfaces are compared under the applied voltage and after removing of the electrical stress. The obtained results are interpreted, as occurrence of an electrostatic possess at the metal/dielectric interface, which may initiate the pre-breakdown processes. In fact, the results indicate a predominance of the work function parameter vs. the metal's conductivity; this indicates possibility of creation at the metal/dielectric contact of addition

**Keywords :** *Dielectrics, Electrical insulation, Space charge Conduction, work function.*

**PP-V05**

**Investigation of dielectric properties of water dispersion of reduced  
graphene oxide/water nanofluid composite**

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In nanofluid composites, competing interactions, interplay and proximity effects at the interface between the different constituents often lead to interesting properties physical, sometimes to novel effects and, to new functionalities. In this paper, we focus our interest on the electrical and dielectric properties of graphene oxide (GO)/water nanofluid composite and to their modeling. These properties were reported in the frequency range 100 Hz–15 MHz and in the temperature range from 295 to 309 K. The temperature dependence of the DC electrical conductivity shows a typical effect of the negative temperature coefficient in resistivity (NTCR) of this material. The mechanism responsible for the change in resistivity is probably predominantly tunneling, wherein the GO particles are not in physical contact and the electrons tunnel through the water gap between them. The DC electrical conductivity obeys an Arrhenius law below and above a critical temperature, and allows us to calculate both activation energies. Moreover, the dielectric response was analyzed using complex permittivity and modulus formalisms, depending on the temperature of measurement. A relaxation phenomenon is induced in the nanofluid suggesting that the presence of the GO particles greatly affects the dielectric properties of the water due to the polarization phenomenon created by them. Havriliak–Negami model was used to fit the experimental results.

**Keywords:** *Nanofluid, complex permittivity, dielectric properties, relaxation, Havriliak-Negami model*

**PP-V06**

**Ureasilicate organic-inorganic hybrids doped with heteropoly acid**

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Main goal of the present work is synthesis of proton-conducting membranes by addition of heteropoly acid in organically modified silicate host materials (ORMOSILS). The samples were obtained by sol-gel approach from two different ureasil organic-inorganic hybrid monomers with different length of polymer segments. The monomers were prepared by rapid uncatalyzed reaction between amino and isocyanate functional groups within compounds of two modified silica ethoxide and polyetheramine. In particular, O,O'-bis(2-aminopropyl)-polypropylene glycol)-block-polyethylene glycol-block-polypropylene glycol-500 (Jeffamine ED-600) and (triethoxysilyl)propyl isocyanate (ICPTES) were used for synthesis of the first monomer and (aminopropyl)triethoxysilane (APTES) and 3-(triethoxysilyl)propyl isocyanate (ICPTES) were used for synthesis of the second monomer respectively. The incorporated heteropoly acid (phosphotungstic acid) acts simultaneously as a source of mobile protons and as a catalyst, initiating the hydrolysis/condensation reactions of the sol-gel composite.

Ionic conductivities, measured at room temperature for the membrane, obtained from the first monomer are of the order of  $10^{-5}$  S/cm and for the second one – about  $10^{-8}$  S/cm.

It was established that the proton conductivity of the membrane, prepared from the first monomer strongly depends on the degree of humidification of the atmosphere at which the measurement is performed. The membrane with lower proton conductivity demonstrated weakly dependent on the humidity of the medium.

**Keywords :** *Proton conducting membranes, Ureasils, Ionic conductivity*

**Acknowledgment:** The authors are grateful for the final support of National Scientific Program "Low-carbon energy for transport and domestic use" – E+ (Contract D01-2014 /28.11.2018) with a leading scientific organization Bulgarian Academy of Sciences, BULGARIA.

The study has been carried out using facilities of ESHER funded by the Ministry of Education and Science, Contract No. Д01-160/2018.

**PP-V07**

**Investigation of linker rotation dynamics in ZIF-8, ZIF-67 and ZIF-90  
metal-organic frameworks using broadband dielectric spectroscopy**

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Metal–organic frameworks (MOFs) - ordered arrays of metal-based inorganic building blocks interconnected by polytopic organic ligands (linkers) - attracted exceptional attention as efficient materials for gas adsorption, separation and future electronics. Choosing of specific metal centers and design of organic linkers allows relatively simple tuning of properties of these materials towards enhancement of their capabilities. Recent studies have shown, that often organic linkers possess some type of flexibility or rotational mobility, which is a contrasting characteristic in respect to other porous materials like zeolites and might be responsible for unique properties of MOFs [1]. Our investigations of dielectric properties of ZIF-90 MOFs showed, that broadband dielectric spectroscopy could be used to probe linker rotation dynamics and the influence of adsorbed molecules [2]. In order to investigate the influence of interexchange of different metal centers and organic linkers we further investigated dielectric properties of ZIF-8, ZIF-67 and ZIF-90 in the 1 Hz – 1MHz frequency and 200 K – 500 K temperature ranges. Analysis of measured complicated dielectric spectra allowed us to distinguish several relaxation processes caused by lattice and adsorbed polar molecule dynamics. Temperature evolution of these relaxation processes and influence of surrounding gas atmosphere was analysed in order to identify and characterise linker rotations in these MOFs.

**Keywords :** *Metal–organic frameworks, dielectric spectroscopy, ZIF.*

**References :**

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**PP-V08**

**Encapsulation of TiO<sub>2</sub> nanosized particles in ureasil organic–inorganic hybrid obtained by sol-gel method**

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In the present work we have summarized recent experimental results about ureasil based organic-inorganic hybrids, with embedded TiO<sub>2</sub> photocatalytic nanoparticles. The ureasilicate materials (ureasils) were synthesized by hydrolysis and condensation of organic – inorganic monomer, prepared by reaction between 3-isocyanatepropyltriethoxysilane (ICPTES) and double terminated polyetheramine (Jeffamine). The initial ureasilicate monomer was doped with various amounts of TiO<sub>2</sub> with an average particle size of ~ 30 nm. Orthophosphoric acid was used as a catalyst for the sol-gel process. In order to achieve sufficiently high gelling rate which ensure a homogeneous particle distribution in the volume of the synthesized ureasilicate material, the concentration of the H<sub>3</sub>PO<sub>4</sub> was experimentally determined.

The phase composition, structure and morphology of the prepared samples with embedded TiO<sub>2</sub> particles were characterized by X-ray diffraction analysis, Fourier-transform infrared spectroscopy and scanning electron microscopy. Thermal behavior was examined using thermogravimetric analysis, while the optical properties were studied by electron absorption spectroscopy operating in diffuse reflection mode. Photocatalytic degradation of modeling pollutant malachite green dye was carried out to study the efficiency of the TiO<sub>2</sub>-containing ureasil nanocomposite as a photocatalyst under UV irradiation. It was found that the observed degradation of the pollutant is mainly influenced by properties inherent in the ureasilicate material itself.

**Keywords:** *Ureasil, nanocomposite, photocatalytic nanoparticles*

**Acknowledgment:** The authors are grateful for the final support of National Scientific Program "Low-carbon energy for transport and domestic use" – E+ (Contract D01-2014 /28.11.2018) with a leading scientific organization Bulgarian Academy of Sciences, BULGARIA.

The study has been carried out using facilities of ESHER funded by the Ministry of Education and Science, Contract No. Д01-160/2018.

**PP-V09**

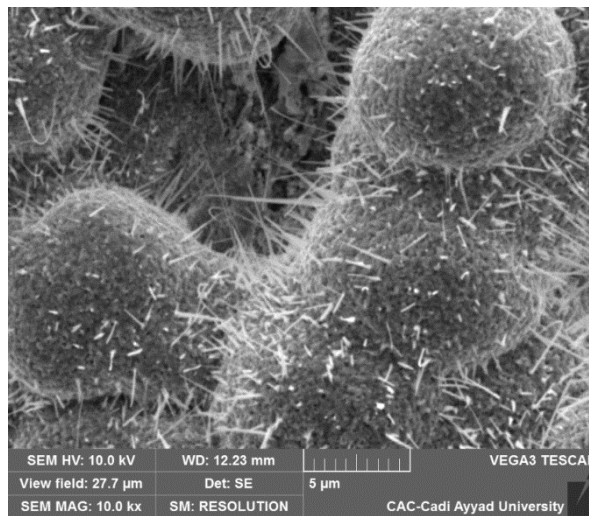
**Optimisation of the density of copper oxide nanowires synthesized by the electrochemical technique followed by annealing**

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Copper thin films were synthesized on FTO/glass substrates using the electrochemical technique (in the potentiostatic mode) at 60°C. Copper sulphate and lactic acid were used as precursors. In this work, we report on the synthesis of the of copper oxide nanowires (CuO NWs) by annealing at 400 °C. In particular, we study the effect of the annealing time (taking 4, 6, 8, 10 and 12 hours, respectively) on CuO NWs density. Characterization will be done by X-ray diffraction, UV-vis spectroscopy and Scanning Electron Microscopy. Other parameters can be also optimized like the annealing temperature and the heating rate.



SEM images for the sample synthesized at 2°C/min for 4h



**PP-V10**

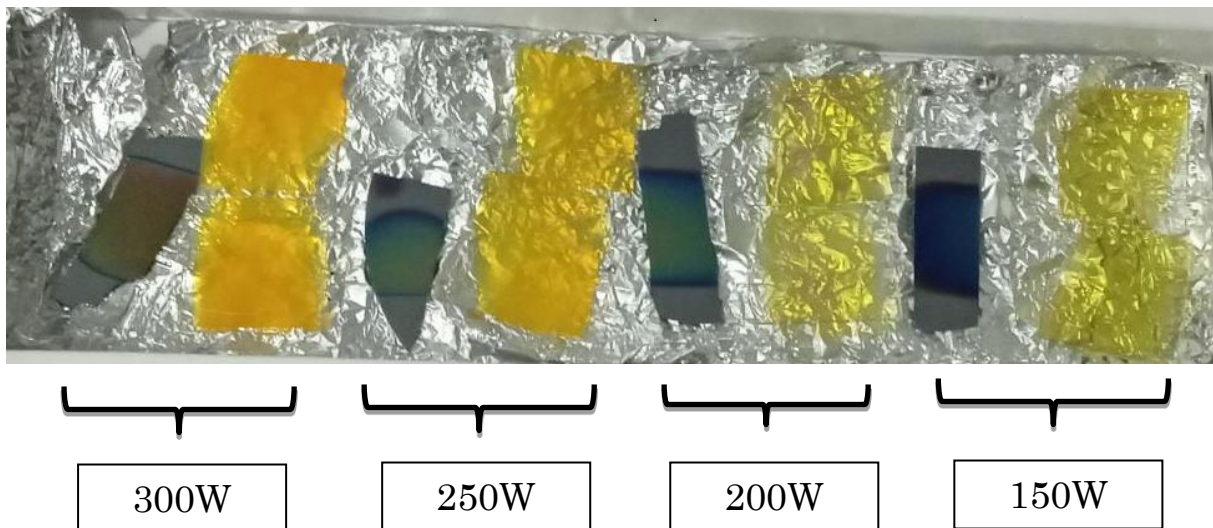
**Effect of RF power and annealing on the structural, optical and morphological properties of RF-sputtered V<sub>2</sub>O<sub>5</sub> thin films**

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Thin films of vanadium oxide were deposited on glass and silicon substrates by radio frequency reactive sputtering from a high purity **vanadium** metal target (99.7%) with a diameter of 10 cm. The reactive sputtering was carried out in an Ar:O<sub>2</sub> gas mixture containing 10% of O<sub>2</sub> and 90% of Ar. The films were deposited at different RF powers (150 W, 200 W, 250 W, and 300 W) for a fixed deposition time of 180 min. X-ray diffractograms showed that the deposited thin films crystallized in an orthorhombic V<sub>2</sub>O<sub>5</sub> phase. It has been found that the crystallite size varies with RF power, and is maximized using 300W of RF power. Scanning electron microscopy (SEM), The Fourier transform infrared (FTIR) spectra and Raman scattering analyzes have confirmed the formation of V<sub>2</sub>O<sub>5</sub> thin films. In addition, Optical transmittance measurements were performed using a Shimadzu UV-PC spectrophotometer in the 200–3200 nm range, it is observed that the optical band gap of the films decreases with the increase in the radiofrequency power.





**PP-V11**

**A comparison of polypropylene-surface treatment by AC corona and dielectric-barrier corona discharges in the air**

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Corona discharge treatment is widely used and has been proven effective in modifying the surface properties of materials, such as wettability, biocompatibility, and surface roughness. This technique has been shown to be useful in increasing the wettability of polymers, resulting in the activation of polymeric surfaces by increasing their surface energy and hydrophilic nature [1]. AC corona discharge at atmospheric pressure represents one of the most complex forms of electric discharges. Its main advantage is that they are rich sources of chemically active radicals, excited and ionized species [2]. Results are presented from experimental studies of polypropylene (PP) films treated by AC corona discharge (point-plan electrode) and AC dielectric barrier corona discharge with point and a dielectric-coated plate electrode configuration the voltage frequency  $f = 1$  kHz. Hydrophobicity of these polymer film surfaces was studied by contact angle measurements. The surface energy of the polymer films was calculated from contact angle data using harmonic mean method. The results show that the corona discharge treatment induces a rapid reduction in the contact angle compared to that recorded with the corona dielectric barrier discharge treatment. All measurements show a typical exponential [ $\sim(1 - e^{-at})$ ] dependence of the polar surface tension on the treatment time  $t$ . The increase can be characterized by a rate constant  $a$ , describing the first order kinetic of the process. Furthermore, a saturation surface tension can be defined, which is independent on the peak voltage used and of all discharge parameters, whereas the time constant depends strongly on the type of discharge. The FT-IR/ATR, SEM, and XPS results showed that AC corona treatment was bigger effectively improve in the wettability of polypropylene surface than the AC dielectric-barrier corona discharges.

**Keywords:** *AC Corona discharge, AC dielectric barrier corona discharge, polypropylene.*

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**PP-V12**

**Effect of different plasma working gas mixtures on the decontamination of fungus polluted water**

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Atmospheric pressure plasma jets (APPJs) are known to have an anti-microbial potential. A setup has been adapted for plasma based liquid treatment where the APPJ is obtained at the exit of a long plastic tube by inserting a floating copper wire inside it. This allows the transport of sufficient energy to regenerate the plasma jet; which has been completely immersed in water contaminated with fungus in order to obtain plasma activated water (PAW). Studies has found that plasma activated water has a particular potential of limiting or/and preventing micro-organisms growth and reproduction as it contains relatively high concentrations of Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS). Those chemical species generated with the intermediate of plasma in PAWs are the main responsible factors of its anti-microbial activity. The type nature and also the concentration of those species are found to be highly related to the nature of the working gas used to ignite plasma[1, 2].

The effect and efficiency of different working gases has been investigated; He + air, He + O<sub>2</sub> and He + N<sub>2</sub>O have been introduced separately through the plasma reactor for a direct treatment of the fungus contaminated water. The active species in plasma are obtained following specific physiochemical reactions that differ from gas to another. The study has been performed on two types of fungus the *Fusarium culmorum* and the *Alternaria graminicola*, those fungus are from different families, however both are known to be highly infectious to plants and seeds and even crops.

The results illustrate the treatment based on He + N<sub>2</sub>O as working gas leads to water decontamination in the average of 5 minutes while the mixture of He + Air takes up to 25 minutes. In contrast the use of He + O<sub>2</sub> is found to have an opposite effect as it allows the growth of both fungus after treatment.

**Keywords:** *plasma, water decontamination, fungus, reactive Nitrogen species, reactive Oxygen species.*

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**PP-V13**

**A possible crosslinking behavior of crosslinkable Silane-XLPE HV insulation under cyclic accelerated weathering aging**

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Silane-crosslinked polyethylene (Si-XLPE) is the first candidate polymer that can be used in the photovoltaic systems connection cables because its resistance to the weathering conditions. The idea of the carried out work in this paper is how we can benefit from the existing weathering conditions that looked to be similar to those necessary in silane-cross-linking process of polyethylene to enhance the crosslinking capability? The adopted methodology consists to conduct a long-term cyclic accelerated weathering aging in the QUV aging test cell on the extruded silane-grafted polyethylene films (cross-linkable polyethylene). The possible crosslinking behavior and the photo and thermo-oxidation degradation were assessed by macroscopic (Hot-Set-Test and mechanical properties) and microscopic (FTIR) technics. The obtained results highlight that the applied cyclic weathering aging leads to an outcome crosslinking reaction. The crosslinking degree increases progressively with aging time leading to an elastic behavior of the polymer. More the crosslinking degree increases more the Hot-Set-Test elongation decreases. The macroscopic observations agree well with the FTIR measurements where we have noticed big changes in the digital fingerprint of the material. The changes in the digital fingerprint are caused by transformation of silane into Si-O-Si links. The absorption band of Si-O-Si links at 1030 cm<sup>-1</sup> was found to be increase with aging time. Beside this, it is evidenced from our study that mechanical properties and carbonyl index behave in very similar way (increase in the former leads to the decrease in the latter in each case) which put in evidence that the same mechanisms are responsible for both behaviors. The probable scenario for this behavior is that the oxidation process leads to chain scission process. The chain scission has a dramatic effect on the mechanical properties that decrease in fast way. The overall conclusion is that the possible crosslinking is done in three steps: initiation, propagation and termination.

**Keywords :** *Silane-XLPE, Weathering aging, QUV, Hot-Set-Test, FTIR.*

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**PP-V14**

**Electrical and optical properties of room temperature potassium niobate  
single crystals**

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Potassium niobate (KNbO<sub>3</sub>), a perovskite-type ferroelectric material isostructural to barium titanate (BaTiO<sub>3</sub>), falls among the most known technologically relevant ferroelectric oxide materials having large spontaneous polarization, remarkable optical anisotropy and interesting nonlinearities for optical and electrooptical applications in single monodomain crystals as well as in periodically poled optical superlattices (PPKN). At room temperature this material belongs to the orthorhombic mm2 class with cell parameters  $a=5.6896\text{\AA}$ ,  $b=3.9692\text{\AA}$  and  $c=5.7256\text{\AA}$  and spontaneous polarization ( $P^{\text{spn}}=0.41\text{C/m}^2$ ) parallel to the c-axis. In contrast to BaTiO<sub>3</sub> and PbTiO<sub>3</sub>, KNbO<sub>3</sub> is, at room temperature, a biaxial material having three refractive indices  $n_1=2.2801$ ,  $n_2=2.3296$  and  $n_3=2.1687$  ( $n_2>n_1>n_3$ ) for light polarized, respectively, parallel to the three crystallographic axes a, b and c of the nonprimitive orthorhombic unit cell. Similar to BaTiO<sub>3</sub>, KNbO<sub>3</sub> has four phases: the first is centrosymmetric non ferroelectric with a cubic structure stable at high temperature, while the three others are non-centrosymmetric ferroelectric with a tetragonal, orthorhombic and rhombohedral structure stable, respectively, below the transition points at  $T_{\text{CT}}=418^\circ\text{C}$ ,  $T_{\text{TO}}=203^\circ\text{C}$  and  $T_{\text{OR}}=-50^\circ\text{C}$ .

Here we present a theoretical approach for studying the spontaneous polarization and refractive indices of orthorhombic KNbO<sub>3</sub> at room temperature. Our approach, which is a microscopic quantum model based upon the orbital approximation and the dipole-dipole interaction due to the local electric field acting on the constituent ions, takes into account the anisotropy in the first-, second- and third-order electronic polarizabilities of all constituent ions, their ionic shifts as well as the crystalline deformations.

The calculation shows that the experimental data of the spontaneous polarization and refractive indices is successfully explained by considering the nonlinearity and anisotropy of the first-, second- and third-order electronic polarizabilities of the constituent ions, particularly that of the O<sub>II</sub> and O<sub>III</sub> ions. Furthermore, The local electric fields of these two ions are inclined in the xz-plane, respectively, by  $\theta=-45.76^\circ$  and  $\theta=+45.76^\circ$  to the polar axis.  $P^{\text{spn}}$  is found to measure  $0.4695\text{C/m}^2$ , while  $n_1$ ,  $n_2$  and  $n_3$  are 2.2508, 2.3540 and 2.2378, respectively.

**Keywords:** *Potassium niobate, Spontaneous polarisation, Refractive indices, Ionic shifts, Crystalline deformations, Electronic polarizabilities, Orbital approximation, Dipole-dipole interaction.*

**PP-V15**

**DFT investigation of structural, electronic and optical properties of  
lithium niobate in its ferroelectric phase**

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Lithium niobate (LiNbO<sub>3</sub>) belongs to the class of ferroelectric oxides, like lithium tantalate (LiTaO<sub>3</sub>) and barium titanate (BaTiO<sub>3</sub>). Due to its large spontaneous polarization, its remarkable optical anisotropy and its non-linear optical activity, LiNbO<sub>3</sub> has many technological applications in the fields of optoelectronics, acoustoelectronics and photonics. LiNbO<sub>3</sub> has only two phases, both with trigonal symmetry: the first phase, which is stable below the Curie temperature ( $T_c = 1210$  °C), is a ferroelectric phase with the space group R3c; the second phase, which is stable above the Curie temperature, is a paraelectric phase. In this work, we present a theoretical study of the structural, electronic and optical properties of the ferroelectric phase of lithium niobate single crystals. The calculations were carried out using the pseudopotential method with an exchange correlation functional considering the local density approximation (LDA) within the framework of the density functional theory (DFT) using Quantum Espresso package. The results show that the calculated value of the energy gap at the centre of the Brillouin zone, which is 2.54 eV, is underestimated compared to the experimental value. Moreover, the upper valence band and the lower conduction band consist mainly of the O-2p and Nb-4d states. Furthermore, by using the modern theory of polarization, the calculated spontaneous polarization of lithium niobate, which is 0.74 C/m<sup>2</sup>, is in good agreement with the measured value. The ordinary and extraordinary refractive indices as well as the optical birefringence are also discussed as a function of the wavelength of the incident light.

**Keywords:** *Lithium niobate, Density Functional Theory, Quantum Espresso, Electronic properties, optical properties.*

**PS**

**PS-01**

**Ultra-Wideband Planar Multilayer Absorber Based on Long Carbon  
Fibers Loaded Epoxy Foam Composites**

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For multilayer absorbers, electromagnetic (EM) waves should be transmitted from one layer to another with minimal reflections between the different layers, and with a gradual dissipation inside these layers. Therefore, a gradual decrease of impedance, and so, increase of the complex dielectric and/or magnetic properties in depth should be ensured. Moreover, today, in commercial multilayer absorbers, the same thickness is used for each layer; this thickness can be monitored in order to optimize the absorption performance of the multilayer. However, it is difficult to choose the appropriate dielectric properties and thickness of each layer amongst a big database of materials. Therefore, genetic algorithm (GA) optimizer could be used.

In our lab, carbon fibers (CFs) loaded epoxy foam composites are studied as EM absorbing materials. Different lengths and weight percentages of the CFs are used, thus allowing to a large panel of dielectric properties.

In this work, a MATLAB code is developed to calculate the reflection coefficient of a multilayer absorber. The GA optimizer is associated to this developed code in order to test, within different iterations, different thickness and compositions of the layers, in order to achieve the reflection coefficient of our goal.

Our optimization allows to a multilayer absorber MLA98-GA, with 98 mm total thickness. The simulation result of this multilayer presents a reflection coefficient less than -20 dB in the entire studied frequency range between 0.75 and 18 GHz. This prototype is achieved and measured; this measurement is compared to simulation one and to the performance of commercial multilayer absorber.

*Keywords: Multilayer absorber, genetic algorithm, ultra-wide band, absorption.*



**PS-02**

**Hybrid material to broaden the absorption bandwidth of a metamaterial absorber**

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Many efforts have been made in the literature to broaden the absorption bandwidth of electromagnetic metamaterial (MM) absorbers. From them, we may cite: combining multiple resonators, stacking different MMs in a multilayer structure, stacking metallic/dielectric layers in pyramidal or cylindrical forms, or incorporating lumped elements into the MM resonators. Most of these methods have failed to cover several bands; indeed, these methods have mostly focused on only one or two frequency bands among the C, X, Ku or K bands, and only few MM designs were reported so far for the absorption in the S-band. The objective of this work is, firstly, to propose a novel MM absorber with multiple resonances in the frequency band between 2 and 18GHz, and secondly, to broaden the absorption bandwidth, using a simple method, of this MM absorber.

In this work, the design of the proposed MM will be presented; it consists of unit cell with dimensions of 15x15mm<sup>2</sup>, composed of different symmetrical resonators, made of copper layer deposited on FR-4 dielectric substrate of 3.2mm thickness. The simulation and the measurement of the reflection coefficient of this MM are conducted; they show a very good matching thus confirming the multi-resonant structure that exhibits several distinct resonances between 2 and 18GHz.

In order to broaden the absorption bandwidth of the proposed MM absorber, a compact hybrid absorber is made by the association of a thin (13mm) and planar dielectric absorbing layer (based on carbon fiber loaded epoxy foam) to the front of a multi-resonant MM. A reflection coefficient less than -10dB (absorption higher than 90%) is then obtained for this hybrid material between 2.6 and 18GHz by simulation and by the measurement of the achieved prototype.

Finally, a comparison between the obtained results and thus of literature will be made in term of thickness and absorption bandwidth.

**Keywords:** *Metamaterial, hybrid absorber, ultra-wide band, absorption.*

**PS-03**

**Comparison of poled glass SIMS data with concentration profile  
simulations and corresponding refractive index**

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Glass poling is a process in which alkali and earth alkali ions from near surface volume of glass drift into the bulk of the sample under the influence of the electric field and moderately elevated temperature. There is a significant interest in glass poling due to its possibility to produce waveguides, glass-metal nanocomposites and microstructures on the glass surface. Glass poling is a complex process involving several types of ions and parameters such as temperature, electric field strength, various atmospheres,... Poling is still not understood well enough, so a better theoretical framework could elucidate the underlying processes. Poling process was investigated by comparison of experiment and simulation. Dielectric constant (refractive index) depth profile of the poled glass was modelled and compared to ion concentration depth profile provided by SIMS (secondary ion mass spectroscopy). Also, ion concentration depth profile of soda-lime glass was simulated using numerical differential equations. Model presumption is that time evolution of ion concentration is guided by drift and diffusion currents. Spatial variation of the electric field upon redistribution of charges with respect to their initial concentration is guided by one dimensional Poisson equation. Broader theoretical knowledge of the poling process was acquired by optimising the properties of mobile ions contained in glass.

***Keywords:*** *thermal glass poling, concentration profiles, diffusion, optical characterization*

## PS-04

### Characterization of Liquid Crystals recovered from End-of-Life Liquid Crystal Displays using Dielectric Spectroscopy

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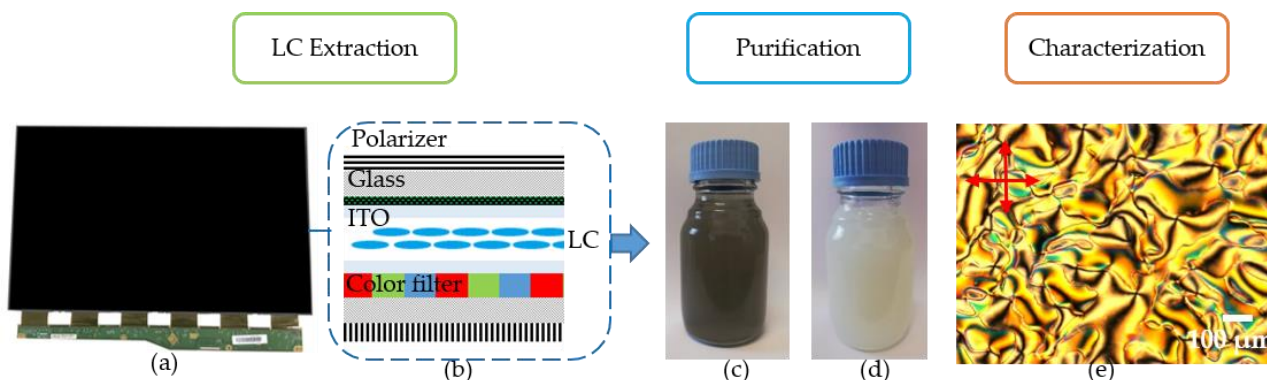
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For several decades, Liquid Crystal Displays (LCDs) have been widely used in televisions, laptops, mobile phones, and other devices. Nowadays, LCs represent an important economic value of the recycling system of LCDs. The reuse of these organic molecules could become a profitable basis since it allows to preserve the value of these materials.

In the present work, the dielectric properties of recycled LCs (non-purified, purified and doped with diamond nanoparticles (DNPs) at 0.05, 0.1 and 0.2 weight%) were investigated. The LC mixtures were obtained from industrial recycling of end-of-life LCDs, presenting mainly a nematic phase. A particular interest is given to DNPs to study their impact on mobile ions present in the recovered LCs. Dielectric measurements were carried out using an impedance analyzer on a frequency range from 0.1 to  $10^6$  Hz, and the anchoring conditions were investigated (planar and homeotropic alignments). All experiments were performed at room temperature and the amplitude of the oscillating voltage was fixed at 1 V. Results show that the dielectric anisotropy for all purified samples presents positive values and a decrease was detected after the addition of DNPs to the LC mixtures. DC conductivity values were obtained by applying the universal law of dielectric response proposed by Jonscher. In addition, results reveal that the conductivity of the doped mixtures is lower than that of the undoped and non-purified LC in planar and homeotropic alignments.

**Figure 1:** (a) End-of-life LCD, (b) Composition of LCD, (c) Non-purified and (d) purified LCs mixtures and (e) Texture of purified LC mixtures observed under polarizing optical microscope presenting a nematic Schlieren texture. Conditions: Crossed polarizers and room temperature.



**Keywords :** nematic liquid crystals; recycling; dielectric properties.

**PS-05**

**Dielectric properties of dispersions of nanoparticles in  
polymer/liquid crystal films**

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Hybrid materials composed of acrylate polymer, nematic liquid crystal and diamond nanoparticles (average diameter 10 $\mu$ m) were elaborated by a phase separation process induced by UV-visible light and studied by different means such as differential scanning calorimetry, polarized optical and scanning electron microscopies, electro-optical and dielectric characterization devices. Several concentrations of liquid crystal (50 to 70 weight-%) and diamond nanoparticles (0 to 1 weight-%) have been employed.

The morphology of the elaborated polymer/liquid crystal systems depends in particular on curing light intensity and diamond concentration; when the latter one is higher than 0.25 weight-%, aggregation of nanoparticles is observed. Otherwise, calorimetric measurements show that the presence of diamond leads to a decrease of both polymer glass transition and nematic-isotropic transition temperatures.

Furthermore, even a small concentration of diamond nanoparticles greatly influences the electro-optical response of the prepared polymer/liquid crystal/diamond systems. In particular, the studied materials present higher switching voltages and lower transmittance in the ON state, compared to the system without diamond nanoparticles. Electro-optical measurements were carried out as function of film thickness.

The dielectric investigation focused primarily on the determination of permittivity, conductivity, and dielectric loss of these hybrid materials in a frequency range comprised between 20Hz and 1MHz. In particular, the presence of diamond nanoparticles allows a strong reduction of the electrical conductivity.

**Keywords :** *nematic liquid crystals; nanoparticles; dielectric properties.*

**PS-06**

**High power microwave absorbers based on glass foam composites**

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In order to save natural resources and reduce energy costs, glasses are often remelted and recycled. But while conventional glasses from bottles and jars are 100% recyclable and reused in the production of new containers, special glasses pose a tougher problem. As heavy-metals containing materials, glass wastes from electronic industry need to be treated separately in a specific recycling branch, if that were at all economically viable. The Cathode Ray Tubes (CRT), found in older style TV screens and monitors, are such emblematic e-wastes from glass industry. Mainly polluted with lead, strontium and barium, those CRT TVs and computer monitors form hazardous waste piles and, as this technology is obsolete, they cannot be used as a raw material again. Foam glass manufacture is a promising mode for re-using these CRT glasses; depending on the foaming process, this cellular material combines low density, low thermal conductivity and excellent thermal stability. For this work, we focused our attention on EM absorptive properties of those CRT cullet based glass foams. Inorganic additives can be used to reinforce the shielding properties in a microwave range. Indeed, when carbon is used as the foaming agent, high dielectric losses are observed in the X-band, making of these foams a good candidate for EM absorbing applications [1,2]. In this work, we will first show the impact of the carbon rate on the density and the microwave behavior of these glass foams. Then, the simulation and the measurement results of the thermal stability and the high power microwave absorbing application of these composites will be presented and discussed.

**Key Words:** *Glass foam, electromagnetic absorption, carbon, CRT, porous structures*

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**PS-07**

**Effect of fiber length on microwave absorption frequency band of  
composites based on carbon fiber loaded epoxy foam**

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Over the past decade, carbon fibers (CFs) have attracted worldwide interest as reinforcement in composite materials for several applications thanks to their electrical conductivity, high corrosion resistance, low density and low cost. Moreover, the composites loaded with carbon fibers have received great attention due to the high electrical conductivity of the fibers which make such composites as ideal candidates for electromagnetic (EM) shielding, for which, high microwave dielectric properties are needed.

In our team, we proposed light-weight epoxy foam filled with very low weight percentages (< 1 wt.%) of CFs as microwave absorbing material. The low real part of the permittivity and high dielectric losses of this material make it ideal for the absorbing application. It is developed as an alternative solution of the commercial polyurethane absorbers loaded with volatile carbon black used in anechoic chambers. Compared to commercial absorbers, our materials showed a very good absorption performance with very low CFs loads. Since, different studies were conducted on the optimization of the dispersion of CFs in the epoxy matrix and on the dielectric properties of these materials as a function of amount and length of carbon fibers.

In this paper, the effect of carbon fiber length on EM absorption, especially on the absorption frequency band, is investigated. Measurement, in free space, of the dielectric properties of different composite samples shows a relation between the absorption frequency band and the length of carbon fiber. This relation appears clearly on the measurement of the reflection coefficient of samples. Furthermore, to confirm this relation, prototypes loaded with long or short carbon fiber length are realized and characterized. Results confirm an improvement in absorption performance on the low frequency or high frequency depending on the choice of CFs length. These results are also compared to the performance of the commercial absorbers.

**Keywords :** *Carbon fibers, Dielectric materials, Microwave absorption, Epoxy foam, composites*



**PS-08**

**Fabrication of well-controlled ferroelectric tunnel nano-junctions in  
P(VDF-co-TrFE) thin films by using Conductive-AFM**

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In the frame of the FEOrgSpin project (*Ferroelectric control of organic/ferromagnetic spinterface*) funded by the National French Research Agency (ANR), one of the objectives is to control the hybrid ferroelectric organic/ferromagnetic metal interface, as known as “spinterface”, for the development of future advanced data storage devices based on spin electronics. For example, the spin polarization of spinterface at the Fermi level can be different or even of opposite sign to that of the adjacent ferromagnetic electrode, annihilating the spin properties of the device.

Recently, we demonstrated the possibility of modulating the spin polarization at the poly(vinylidene fluoride) (PVDF)/Co interface by changing the direction of the ferroelectric polarization within the PVDF material [1]. We obtained important results regarding the surface morphology, the conduction properties as well as piezo-/ferroelectric behaviour of these organic ferroelectric barrier layers by using different techniques/tools of Atomic Force Microscopy (AFM), such as Piezoelectric Force Microscopy, for nanoscale investigation. Now, in order to optimize the parameters of spin transfer, it becomes necessary to develop nanometric-size organic tunnel junctions to improve the effects of both electroresistance (TER) and magnetoresistance (TMR) [2]. The solution chosen consists in the development of tunnel nano-junctions indentation by the use of conductive-AFM probes (CT-AFM) [3]. Here the feedback control of the process is operated by the current measurement during indentation and allows for a sub-nanometer control of the thickness of the junction.

**Keywords:** *Tunnel nano-junctions, P(VDF-co-TrFE), Fabrication, Control, Conductive-AFM*

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**PS-09**

**2D material dependence on the crystallization and ferroelectric properties  
in organic P(VDF-co-TrFE) thin films**

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Ferroelectric polymer/2D materials hybrid systems have received considerable attention due to their promising utilization in advanced flexible electronics [1]. It is well-known that the crystallization process of ferroelectric polymers such as poly(-vinylidene fluoride-trifluoroethylene) (P(VDF-co-TrFE)) strongly affects the electronic properties of the hybrid structures.

Here, the effect of graphene and hexagonal boron nitride (*h*BN) 2D materials onto the structural, morphological, and piezoelectric/ferroelectric properties of P(VDF-co-TrFE) thin films is reported. Particularly, the 2D material dependence on both the polarization switching behavior and the piezoelectric coefficient is locally demonstrated. Indeed, it is shown that coercive voltage does not only depend on the P(VDF-TrFE) crystallization temperature and the subsequent thermal treatment. The relationship between structure and piezoelectric/ferroelectric properties is then established. These findings provide useful guidance for fabricating P(VDF-co-TrFE)/2D layer-based flexible electromechanical devices with enhanced performances.

**Keywords:** *Piezoelectricity, Ferroelectricity, P(VDF-co-TrFE), Atomic Force Microscopy, Graphene, Hexagonal boron nitride*

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**PS-10**

**Electric field assisted dissolution of Al and Cu metal thin films**

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Metal doped silica glass is widely used in photonics, photoelectronis, optics as well as in sensing. There are several methods for doping the glass matrix with metal ions, such as often used melted salt ion exchange and much cheaper and simpler process called electric field assisted dissolution (EFAD), used in our laboratory [1-3]. In EFAD process, thin metal films deposited on glass substrate by electron beam evaporation are subjected to moderately elevated temperature and DC voltages. Resulting current induces several consecutive processes: 1) drifting of naturally present alkali metal ions in glass matrix toward cathode, leaving the subanodic layer depleted of charge carriers; 2) dissolution of thin metal film and 3) subsequent travelling of dissolved metal ions into the subanodic layer. Unfortunately, the doping process is still not completely unveiled. Therefore, the elucidation of the process itself is extremely important. Herein we present ellipsometry based results of the optical properties of Al or Cu EFAD doped glass. Doping with metal ions and depletion from alkali ions are processes that take place simultaneously, but each with its own dynamics. As a consequence, the refractive index in the subsurface layer of the EFAD doped glass changes with the course of the process. Besides this, the refractive index is not constant through the thickness of the affected region since concentration of the dopant metal ions, as well as alkali ions, is not homogeneously distributed.

**Keywords:** *electric field assisted dissolution, metal thin films*

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**PS-11**

**Microstructure and nanoscale piezoelectric properties in  
Ba<sub>0.85</sub>Ca<sub>0.15</sub>Ti<sub>0.9</sub>Zr<sub>0.1</sub>O<sub>3</sub> (BCTZ) thin films grown by pulsed laser deposition**

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In the frame of an innovative project entitled “Optimization of piezoelectric properties in eco-responsible functional oxides for energy harvesting” and supported by the *Hauts-de-France* Region (France), lead-free Ba<sub>0.85</sub>Ca<sub>0.15</sub>Ti<sub>0.9</sub>Zr<sub>0.1</sub>O<sub>3</sub> (BCTZ) <sup>[1]</sup> thin films have been successfully grown on (001)-oriented SrTiO<sub>3</sub> (STO) substrates by pulsed laser deposition (PLD). Using high-resolution X-Ray diffraction, structural and microstructural properties of the films have been highlighted. As deduced from the  $2\theta$ - $\omega$  X-Ray patterns, the BCTZ films appear highly (00l)-oriented, showing no secondary orientation or other phase. The narrow rocking-curve, i.e. 0.08° width for 002<sub>BCTZ</sub> peak, demonstrates the sharp mosaicity of the films as compared to the 0.06° width measured for the 002<sub>STO</sub> peak of the substrate. Considering the tetragonal structure for the films and taking into consideration the expected (111)-reflection position for measurement, phi-scan recording confirms the existence of the epitaxial growth of BCTZ on STO while reciprocal space map evidences the out-of-plane direction relationship [001]<sub>BCTZ</sub>//[001]<sub>STO</sub>. While the  $2\theta$ - $\omega$  X-Ray measurements and advanced Raman spectroscopy analysis are revealing the coexistence of the orthorhombic and tetragonal structures in BCTZ bulk materials, used as target for PLD, further structural measurements need to be carefully performed in the case of thin films to determine the exact structure. In this presentation, reciprocal space maps recorded around specific expected (*or not expected*) nodes, in relation with the symmetry, will be shown to give an account of the precise structure of our films. On the other hand, using the spectroscopic tool of atomic force microscopy which permits to record piezoloops, preliminary results confirm the ferroelectric state (and then piezoelectricity) of our BCTZ films, when grown on semi-conductive Nb-doped (001)-oriented STO substrates. We conclude that these preliminary results are very attractive for the use of such specific oriented lead-free BCTZ thin films for applications in energy harvesting.

**Keywords:** BCTZ, Thin film, Microstructure, Nanoscale piezoelectricity, Energy Harvesting

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**PS-12**

**Study of the structural, dielectric and ferroelectric properties in  
 $\text{Ba}_{0.85}\text{Ca}_{0.15}\text{Ti}_{0.9}\text{Zr}_{0.1}\text{O}_3$  ceramics**

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Lead-free (Ba,Ca)(Ti,Zr)O<sub>3</sub> ceramics had attracted a broad interest as lead-free piezoelectric materials for application in microelectronic devices. The Ba<sub>0.85</sub>Ca<sub>0.15</sub>Ti<sub>0.9</sub>Zr<sub>0.1</sub>O<sub>3</sub> morphotropic phase boundary (MPB) composition was reported to show enhanced piezo, ferroelectric and tunability properties. This composition being at quadruple point, it is supposed that the maximization of properties is related to its polymorphs' superposition. The large variety of reported properties for the same composition was not fully explained. In various types of samples, the phase composition may change according to the used precursors, synthesis and sintering strategy giving rise to various local compositional and structural heterogeneities, grain sizes, grain boundaries and charge defects. In this work, the Ba<sub>0.85</sub>Ca<sub>0.15</sub>Ti<sub>0.9</sub>Zr<sub>0.1</sub>O<sub>3</sub> ceramics were produced by solid state reaction using conventional ceramic and different grinding ways. We have performed a comparative study at the low and high electric field (dielectric permittivity at different temperature and frequency range, P(E) hysteresis loops and dc-tunability) for prepared BCTZ ceramics with different degree of density. The temperature dependence of the real part of permittivity and dielectric losses at a few frequencies obtained in the investigated BCTZ ceramics present different permittivity value of 1000, and respectively 6800 with the same dielectric losses of about 2%. The switching characteristics revealed a reduction of the coercitivity field from 2.4 to 2 kV/cm, remnant polarization (P<sub>r</sub>) from 4.3 to 3.5 μC/cm<sup>2</sup> and area, in BCTZ sample 1 and BCTZ sample 2, respectively. The samples show a higher value of saturation polarization (P<sub>s</sub> ≈ 3.5 μC/cm<sup>2</sup>) and a more tilted loops, with a low rectangularity factor (P<sub>r</sub>/P<sub>s</sub>), due to the effect of some parameters as local compositional inhomogeneity, local electric field distribution in the materials and the grain size. The effect of electric poling on the structural and piezoelectric properties of the BCTZ samples was analyzed and discussed.

**Keywords:** *dielectric and ferroelectric properties, structural characterization, piezoelectric response*

**Acknowledgements:** This work was supported by Romanian Ministry of Research and Innovation grant, CCCDI-UEFISCDI, project no PNIII-P3-3.1-PM-RO-FR-2019-0069.

**PS-13**

**The role of microstructure on dielectric properties of polymer-based composites: Experiment and modelling**

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Polymer based nanocomposites are in high request both from commercial and scientific points of view due to their improved properties when compared to pure polymers.

The present work is based on the idea that the electrical properties of polymers (e.g. PVDF) matrix may be enhanced by addition of different nanoparticles (e.g. BaTiO<sub>3</sub>, MWCNTs, and metallic nanoparticles). Thus, it was studied the influence of various filler inclusions and shapes of the particles (such as: cubic, spherical and thread/wire) on the dielectric properties of polymer-based composites. By developing numerical methods based on Finite Element Method, it was demonstrated that the addition of nanoparticles with different shape into polymer matrix play an important role in electrical properties. The dielectric experimental results and the predicted theoretical simulations were compared and discussed in detail. The polymer composites as poly(vinylidene fluoride) (PVDF) with different filler of BaTiO<sub>3</sub>, MWCNTs and Ag-BaTiO<sub>3</sub> particles were prepared by melt blending and solution casting methods. The phase composition was investigated by XRD and FTIR analysis. The microstructural features of the composites were examined by TEM and SEM. The dielectric properties were investigated at room temperature at different frequencies (1Hz - 1MHz) in parallel-plate capacitor geometry by using a frequency response analyzer and in the temperature range (20<sup>0</sup>C-160<sup>0</sup>C) for frequency range (20Hz-2MHz). In order to study the effect of the shape of the filler particles in a polymer matrix on effective dielectric properties, we have developed numerical methods by using FEM for simulating 3D realistic microstructures, the local electric fields and effective dielectric properties. The experimental investigations and theoretical simulations have confirmed the major role of shape of filler in a polymeric matrix onto the dielectric response. It has shown that the use of cubic-shaped ferroelectric particles is more advantageous for increasing the dielectric response than the use of spherical particles.

**Keywords:** *polymer composites, dielectric properties, Finite Element Method*

**Acknowledgements:** This work was financial supported by the Romanian MEN UEFISCDI PN-III-P4-ID-PCCF-2016-0175 grant (HighKDevice)

**PS-14**

**Synthesis and dielectric characterization of perovskite (Sr<sub>2</sub>Ta<sub>2</sub>O<sub>7</sub>)<sub>100-x</sub>(La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub>)<sub>x</sub> ceramics : application to dielectric resonator antennas**

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In the search for a new innovative material, meeting the criteria for integration into compact and miniature antenna devices, we were interested in the two ferroelectric perovskite compounds Sr<sub>2</sub>Ta<sub>2</sub>O<sub>7</sub> and La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub>, having, respectively, Curie temperatures (TC) of -107°C and 1461°C. The goal of our study was to determine the optimal composition (x) in the solid solution (Sr<sub>2</sub>Ta<sub>2</sub>O<sub>7</sub>)<sub>100-x</sub>(La<sub>2</sub>Ti<sub>2</sub>O<sub>7</sub>)<sub>x</sub> (STLTO) leading to a TC close to room temperature and to identify compositions with low dielectric losses.

STLTO powder compounds were synthesized in the range  $x \in [0-3]$  by the solid-state chemistry route and ceramics were further sintered at high temperature. Chemical and structural characterizations show that the compounds are pure, crystallizing in an isotype orthorhombic Sr<sub>2</sub>Ta<sub>2</sub>O<sub>7</sub> structure with cell parameters varying linearly as a function of the composition (x), thus demonstrating the formation of an ideal solid solution in the investigated compositional range. Different dielectric characterization techniques, ranging from a few kHz to a few GHz, have been performed, showing an almost identical evolution of the permittivity as a function of the composition, namely, a maximum for the composition (x) between 1.5 and 2. Low dielectric losses ( $\tan\delta < 5 \cdot 10^{-3}$ ) are observed for  $x < 1.5$  and increase above. The permittivity of the STLTO ceramics varies with temperature for each composition; furthermore, Polarization - Electric field (P-E) measurements show hysteresis polarization loops for  $x \geq 1.65$  which confirms the ferroelectric nature of the STLTO compounds. Measurements of the permittivity under dc bias highlight a tunability that exceeds 50 % under 30 kV/cm at 10 kHz for the composition  $x = 1.65$ .

As ceramics, the STLTO paraelectric compositions  $x < 1.5$ , for which moderate permittivities ( $< 100$ ) and very low losses ( $< 5 \cdot 10^{-3}$ ) have been measured, were integrated in low profile microwave dielectric resonator antennas (DRA). A first prototype, incorporating the STLTO  $x = 0$  ceramic (i.e. Sr<sub>2</sub>Ta<sub>2</sub>O<sub>7</sub>), was produced and measured. The antenna consists of cylindrical pellet placed above a printed microstrip copper line which excites the dielectric resonator. Experimental results are in very good accordance with the simulation. The achieved DRA structure operates at a frequency of 5.80 GHz; the impedance matching is obtained between 5.64 GHz and 5.93 GHz which corresponds to a bandwidth of 290 MHz (4.9 %) (for  $S_{11} < -10$  dB), associated to a maximum gain of 6.4 dBi. Measurements show a maximum efficiency of 80 % at the resonant frequency.

Keywords : Perovskite, Characterization, dielectric resonator, antenna

## **List of ISyDMA'6 Participants**



*The Sixth International Symposium On Dielectric Materials and Applications (ISyDMA'6)  
Calais, France, December 15-17, 2021*

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HADOUCH	Youness	Morocco	OP-VA10
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LAKOUADER	Afaak	Morocco	PP-V01, PP-V03
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LEMEE	Nathalie	France	Conf 12, PS-11
LEROY	Gérard	France	Conf 01, OP-A02, OP-C04, OP-D03
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<b>PLYUSHCH</b>	<b>Artyom</b>	<b>Lithuania</b>	<b>OP-VC06</b>
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<b>SVIRSKAS</b>	<b>Sarunas</b>	<b>Lithuania</b>	<b>Conf 04, OP-VC07</b>
<b>TACHAFINE</b>	<b>Amina</b>	<b>France</b>	<b>Conf 01, OP-C06, OP-VC03, PS-11</b>
<b>TRIKI</b>	<b>Asma</b>	<b>Tunisia</b>	<b>Conf 18</b>
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<b>VASEASHTA</b>	<b>Ashok</b>	<b>USA</b>	<b>Conf 05</b>
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