

InComEss

Innovative polymer-based composite systems
for high-efficient energy scavenging and storage

Deliverable

D9.7 Mid-term InComEss Workshop

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EXECUTIVE SUMMARY / ABSTRACT

SCOPE

The first project Workshop was held virtually on October 21st, 2021, within the framework of an international conference (*6th Edition of Smart Materials and Surfaces – SMS 2021*) with the aim of targeting main stakeholders such as educational institutes, standardisation bodies, etc., presenting the project goals and overview on the research of smart materials and their expected exploitation for the targeted markets.

I Introduction

As part of the technology transfer activities, the **project Workshop** was organized on **October 21st, 2021**, within the framework of an international conference (*6th Edition of Smart Materials and Surfaces 2021- SMS 2021*¹) with the aim of targeting main stakeholders (industry, education, standardisation bodies, etc.).

Although the **SMS2021 conference**, together with several joint Events such as *Sensors, European and Graphene Forum (EGF)* and *NanoMed 2021*, run from the 20th to 22nd of October in a hybrid mode (online and onsite), InComEss consortium opted to organize the **Workshop** as a **virtual event** due to significant COVID-19 related restrictions on mobility and gatherings in Europe.



Figure 1. SMS 2021 conference and Joint Events²

A wide range of topics³ were covered and several symposiums were held during the SMS 2021 conference (shown in Figure 2) from which *Energy Harvesting, Hybrid Materials* and *Smart Materials* themes were of particular interest in relation to InComEss project. Briefly, the workshop focused on the project dissemination by presenting the overview and project goals as well as ongoing research of smart materials and their expected exploitation for the targeted markets.

SMS 2021 Conference themes are as follow:

- > Advances in Functional and Multifunctional Materials
- > Hybrid materials
- > Shape Memory Materials: State-of-the-art Research and Applications
- > Advances in Multiferroic and magnetoelectric materials and applications
- > Advances in Inorganic Luminescent Materials and Applications
- > Metamaterials and Metadevices
- > Electro-active polymers: current capabilities and challenges
- > Catalytic materials
- > Photocatalytic Materials for Energy and Environmental Applications
- > Energy Harvesting via Smart Materials
- > Materials and Mechanisms of Superconductivity
- > Stretchable and Flexible Electronic Materials & Devices
- > Bioinspired Materials
- > Biomimetic bioactive biomaterials – the novel materials of implantable devices
- > Stimuli Responsive Materials
- > Intelligent drug delivery and release systems
- > New Materials for sensors and actuators: Sensing the Future with New Materials
- > Progress in Wearable/Wireless and Implantable Body Sensor Networks for Healthcare Applications
- > Intelligent Materials for Textiles
- > Fire retardant materials and surfaces
- > Smart Materials & Micro/Nanosystems
- > Graphene and Other Emerging 2D-layered Nanomaterials (**European Graphene Forum 2020**)

In addition to the above **main conference sessions**, the event will host the following **focused Symposia / EU projects workshops**:

Figure 2. Topics covered at the SMS 2021 and Joint Events

¹ <https://www.setcor.org/conferences/sms-2021>

² <https://www.setcor.org/conferences/sms-2021/conference-program>

³ <https://www.setcor.org/conferences/sms-2021/conference-topics>



2 Agenda

The first workshop of InComEss presented a good opportunity to disseminate the main goals of the project, materials research progress, expected market benefits and exploitation as well as to attract different stakeholders. In this case, it must be noted the attendee's profile at the conference were mainly researchers (doctors, PhD students, Professors) from research/academia. A total of 35 participants assisted to the first project workshop.

21 October 2021		
Smart Materials and Surfaces - SMS 2021 Virtual Session		
Virtual Conference Room 1		
Workshop on InComEss EU Project: INnovative polymer-based COmposite systems for high-efficient Energy Scavenging and Storage		
Session's Chairs: Dr. Cintia Mateo-Mateo, AIMEN, Spain		
08:00 - 08:15	InComEss project overview C. Mateo-Mateo	Dr. Cintia Mateo-Mateo, AIMEN, Spain
08:15 - 08:45	Graphene liquid crystal-based dielectrics P. Poulin	Dr. Philippe Poulin, Centre de Recherche Paul Pascal- CNRS- Bordeaux, France
08:45 - 09:15	Li-ion batteries: characterization using EIS R. Novoa	Dr. X. Ramón Novoa, University of Vigo, Spain
09:15 - 09:30	Development of lead-free piezoelectric fibres N. Azoia	Dr. Nuno G. Azoia, CeNTI, Portugal
09:30 - 09:45	Research on thermoelectric polymer-based composites at IPF Dresden B. Krause	Dr. Beate Krause, Leibniz Institute for Polymer Research, Germany
09:45 - 10:00	Printed monolithic supercapacitor M. Mäntysalo	Prof. Matti Mäntysalo, Tampere Univ., Finland
10:00 - 10:15	Piezoelectric Vibration Energy Harvester – State of the Art Systems Implementations and Economics J. Kunzmann	Dr. Jan Kunzmann & Enrique de Pablo Corona Smart Materials GMBH, Germany
10:15 - 10:30	Development of High Energy Ultracapacitors from an Industrial Perspective M. Klose	Mr. Markus Klose, Skeleton Technologies, Estonia
10:30 - 11:00	Morning Coffee Break	

Figure 3. Agenda of InComEss Workshop^{2,4}

The agenda of the first workshop of InComEss was divided in an introduction of the project followed by the presentation of two invited speakers (Dr. Philippe Poulin and Prof. Ramón Novoa) which continued with the research on lead-free piezoelectric materials, thermoelectric composites, and supercapacitors (InComEss partners) in the project. The last two presentations were focused on expertise of two SMEs (engaged also in the project) which will benefit from the exploitation of the developed smart materials.

Considering the current state of the project, it must be highlighted that the materials research is still ongoing.

⁴ Page 11/18 - conference program

3 Presentations

This section includes some images of the presentations shown in the workshop as per order of Agenda. The recorded session of the Workshop can be found at the conference website², in the following link: <https://drive.google.com/file/d/14YwCEUenV7Wlmc7ivOsz4EY4GqjTrrqf/view>

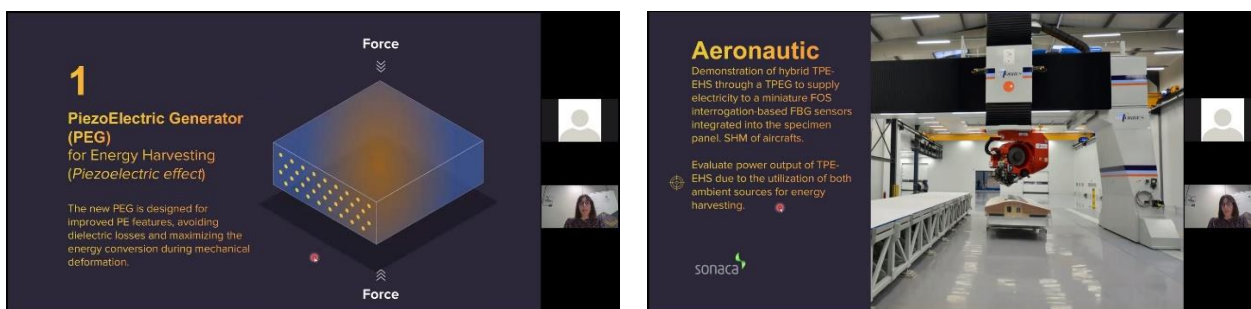


Figure 4. InComEss project overview by Dr. Cintia Mateo (AIMEN)

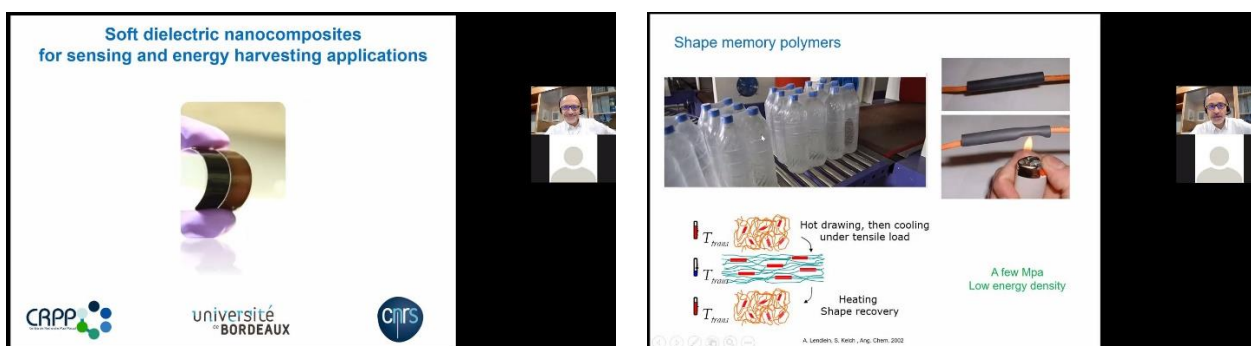


Figure 5. Images of the expertise in soft dielectric composites for sensing and Energy Harvesting applications presented by Dr. Philippe Poulin (invited speaker)

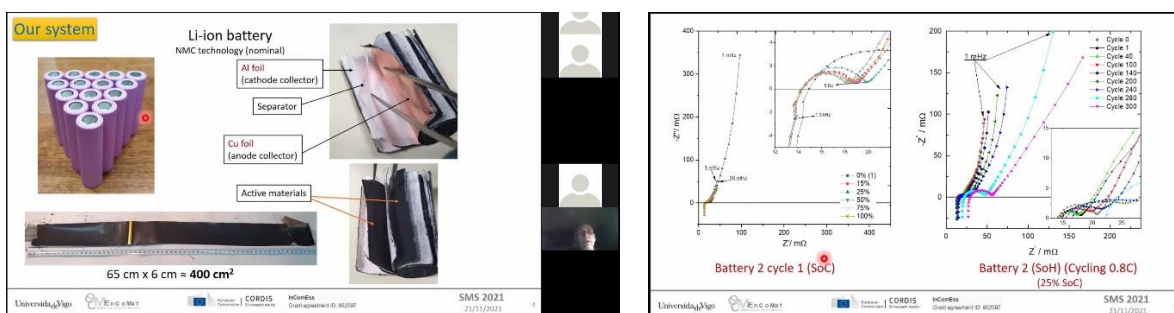


Figure 6. Presentation shown by Prof. X. Ram n N voa (invited speaker) of Li-ion batteries and EIS characterization

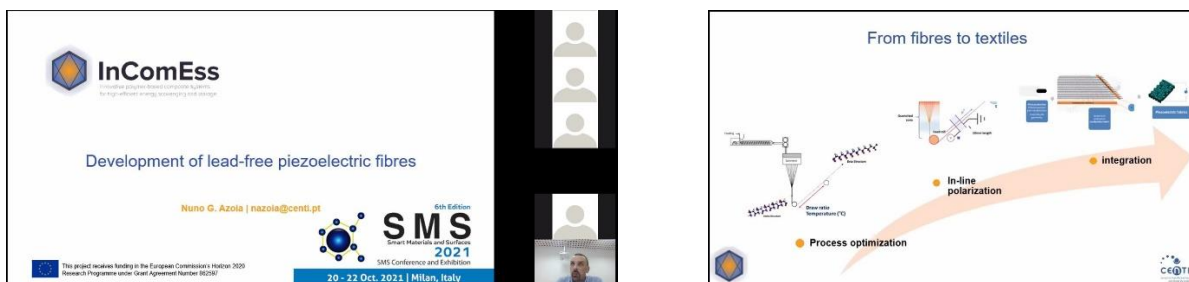


Figure 7. Presentation of lead-free piezoelectric fibres by Dr. Nuno Azoia (CeNTI)



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The project receives funding in the European Commission's Horizon 2020 Research Programme under Grant Agreement Number 101017727

ipf Leibniz-Institut für Polymerforschung Dresden
SMS 2021 Milano, 21.10.2021

Research on thermoelectric polymer-based composites at IPF Dresden

Dr. Beate Krause, Dr. Petra Pötschke

Department of Functional Nanocomposites and Blends
Leibniz Institute of Polymer Research Dresden (IPF), Dresden, Germany

Prototype modules for thermoelectric generators
Melt processed polymer composites

Module 1: 4 thermocouples
Module 2: 49 flexible thermocouples

Proof of concept

Output Voltage (mV) vs. ΔT (K)

p-type: PP + 2 wt% SWCNT + 5wt% CuO
n-type: PP + 2 wt% SWCNT + 5 wt% CuO + 10 wt% PEG

1st cycle, 2nd cycle, 3rd cycle, 4th cycle, 5th cycle

module 2 (49 pairs): 110 mV
module 1 (4 pairs): 21 mV

13 | Lu, G. Corbelli, B. Krause, L. Zhang, T. Chiu, W. Jenschke, M. Ulbrich, W. Tarnat, B. Voit, P. Pötschke. Polypropylene based melt processed composites with single-walled carbon nanotubes for thermoelectric applications: Switching from p-type to n-type by the addition of polyethylene glycol. *Polymer* 2021, 198, 513-520

Figure 8. Presentation on thermoelectric polymer-based composites by Dr. Beate Krause (IPF)

Piezoelectric Vibration Energy Harvester

SMART MATERIAL
State of the Art
System Implementations and Economics

Enrique de Pablo Corona, Dr. Jan Kunzmann | Smart Material Corp. | SMART MATERIAL

Energy Harvesting Applications

- Structural Health Monitoring and other sensors
- Wireless transmission of collected data
- Cantilevers vibrate with wind on facade
- Optimization of cantilever structure and MFC geometry

SHM in Buildings with wind as energy source

Enrique de Pablo Corona, Dr. Jan Kunzmann | Smart Material Corp. | SMART MATERIAL

Figure 9. Piezoelectric Vibration Energy Harvester presentation by Enrique de Pablo Corona (SMRT)

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Printed monolithic supercapacitor

Matti Mäntyselä¹, Jari Keskinen¹
Jürgen Pionteck², Ezgi Inci²

1) Tampere University (matti.mantyselalo@tuni.fi)
2) Leibniz-Institut für Polymerforschung Dresden e.V. (IPF) (pionteck@ipfdd.de)

Tampere University | ipf

Printed electronics - low-cost environmentally sustainable manufacturing

Subtractive process: Etching, Cleaning

Additive process: Inkjet printing, Laser sintering, UV curing, Electrodeposition

- Additive => less material waste
- No etching => less harsh chemicals
- Less process steps => simplified process

Printed Electronics Processing Concept (Smart Structures) | From Dr. G. Corbelli, Institut für Materialwissenschaft der Universität zu Köln

Figure 10. Printed monolithic Supercapacitor by Prof. Matti Mäntyselä (TAU)

SKELE+ON TECHNOLOGIES

Development of High Energy Ultracapacitors from an Industrial Perspective

Markus Klose
Head of Intellectual Property
Skeleton Technologies GmbH

Workshop on InComEss EU Project
Smart Materials and Surfaces - SMS 2021 Virtual Session

Fully integrated manufacturing
High quality & performance energy storage solutions made in Europe

The largest ultracapacitor factory in Europe (Grossröhrsdorf, Germany)

Capacity after current scale-up:

3.5m Cells per year
400k Modules per year

Figure 11. High Energy Ultracapacitors presented by Dr. Markus Klose (SKLT)



4 Questions & answers

The discussions during the questions & answers were centered in:

- Study of percolation behavior when using mixture of platelets and carbon nanotubes and theoretical thermodynamic equilibrium.
- Voltage used for batteries characterization and evaluation of ion diffusivity and loss factors in dielectrics.
- Issues that could arise when combining piezoelectric ceramics and polymers due to their different piezoelectric coefficients.
- Benefits of supercapacitors compared to batteries from performance and environmental point of view, main applications of supercapacitors and device thickness and control.
- Performance comparison between polymer-based lead-free materials vs PZT patches and impact of lead-free materials at industry level (considering the European requirements)
- Cost of ultracapacitors compared to batteries, biggest challenges for ultracapacitors to move into a wider market and performance of curved graphene vs commercial graphene.

5 Conclusions

The first workshop of InComEss was organized as a dissemination event and successfully managed to attract the academia stakeholder profile. In this sense, more technology transfer activities are planned (per GA) to gather all relevant stakeholders from several sectors (industry, standardization bodies, education etc.) to present the main results achieved and expected gains of their deployment in the targeted markets, receive feedback from them and to foster acceptance and integration of the project results in targeted value chains.



I. Annex I. Workshop Participants

In this annex several screenshots of the number of participants who assisted to the project workshop (in a remote manner) are shown. It may be highlighted, InComEss Project could also attract other type of stakeholders, apart from academia/education, considering the recorded workshop is available and open to everyone at SMS 2021 conference website.

