2020 ANNUAL REPORT

BCMATERIALS

BASQUE CENTER FOR MATERIALS, APPLICATIONS & NANOSTRUCTURES

ehu group

Universidad del País Vasco
Euskal Herriko Unibertsitatea

ikerbasque
Basque Foundation for Science

EUSKO JAURLARITZA
GOBIERNO VASCO

Crystallization is a highly effective method for purification of materials. Here, the crude product of a synthesized terpyridine derivative was dissolved in boiling ethanol giving a saturated solution. By slowly cooling down in an oil bath crystals formed. Impurities do not fit in the highly ordered material structure and remained in solution.

Author: Henri Hintz , PhD

2020 | ANNUAL REPORT

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CONTENTS

Enjoy this report, as it truly represents our contribution to a better world allowing to look forward for a next year full of relevant science, discoveries and achievements in the growing excellent environment that BCMaterials represents.

Senentxu Lanceros-Mendez

Ikerbasque Professor / Scientific Director

Another intense year has gone by for our research center. A year with an intensity impossible to summarize in the numbers we provide in this report

The dynamics of the year 2020 has been completely unexpected and certainly will profoundly influence our society and activities for the years to come...

It has been a year that has brought pain, uncertainty and sorrow and that has placed ourselves in from of the mirror of our values, actions, our ability to act, and our solidarity.

It has been also a year that has strongly reinforced the central role of the scientific activity not just to allow the present and to shape our future, but also to rapidly react in the present to provide a future.... to allow a future.

The pandemic situation represented a turning point in our immediate priorities and strong and rapid efforts in the areas of digitalization and biomedicine have been achieved, bringing comfort and hope in this complicated situation. Those areas, together with the efforts for an unavoidable more sustainable future, will shape the scientific and technological efforts in the next decade.

In this context, it has been an extraordinary moment to be the director of a research center such as BCMaterials. The demonstration of the central role of the scientific activity of BCMaterials in areas with profound impact in society, and the dedication, solidarity and compromise of the BCMaterials family with this activity has been stronger than ever. This compromise has allowed not just to achieve the great numbers we have achieved, demonstrating the strong commitment of BCMaterials with excellence science, formation, outreach and technology transfer in all areas in which advanced material play a central role. It also demonstrated the character of a center that works as a team for the benefit of society.

It has been also a year for the integration of new colleagues in BCMaterials, including Ikerbasque Professors, Associate, Fellows, groups from the UPV/EHU, post-doc and pre-doc researchers, to feel the strong support from the Ikerbasque Foundation, the UPV/EHU and the Basque Government, and to consolidate a solid ground aiming for high research achievements in all areas we aim to contribute to.

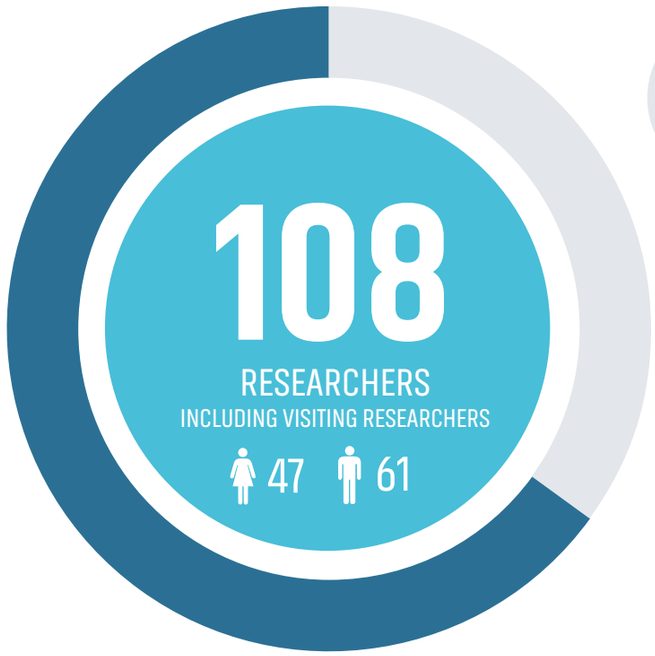
Now that the shadows that 2020 start to mitigate, we can look to this 2021 with the motivation of the relevance of our work to build up a promising future within a new horizon, Horizon Europe, full of challenges and opportunities.

Thus, this report serves not just to provide numbers and achievements, but also to truly thank all of you for the solidarity and commitment in this unforgettable year..

Let´s face the next challenges with the preparation, illusion and devotion that makes any apparently impossible hurdle, fully possible to be overcome!

BCMATERIALS
IN NUMBERS

RESEARCH COMMUNITY



35%
INTERNATIONAL RESEARCHERS

RESEARCH OUTPUT

196
ISI PUBLICATIONS

42
H INDEX

80%
Q1 PUBLICATIONS

3137
CITATIONS

1
BOOKS

19
BOOK CHAPTERS

PROJECTS AND FUNDING

30
ONGOING PROJECTS

3.050.000 €
FUNDING

TRAINING

11
PHD THESIS DEFENDED

10
MASTER THESIS

6
UNDERGRADUATE PROJECTS DEFENDED

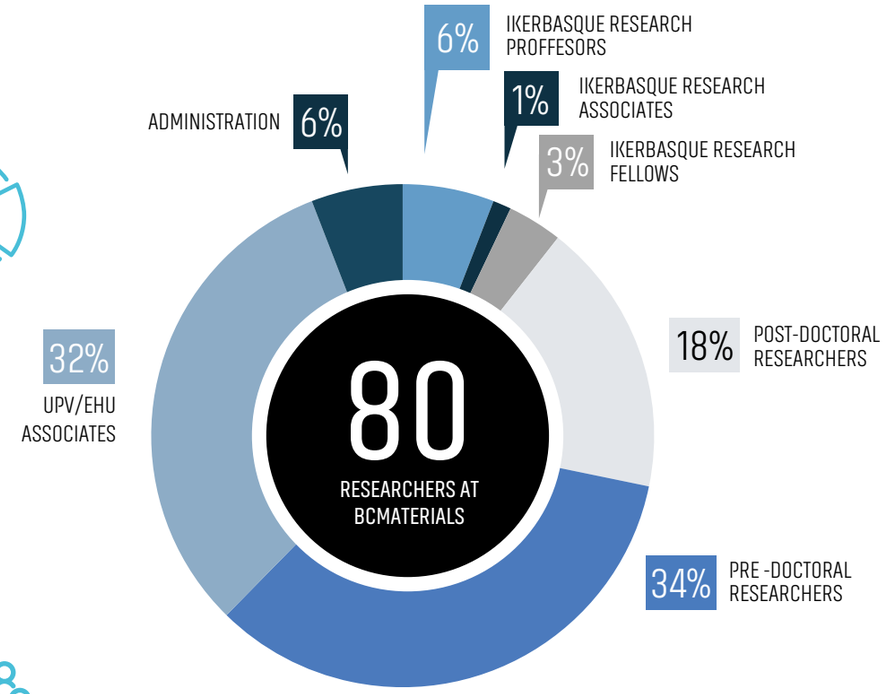
OUTREACH

35
SEMINARS

12
CONFERENCES WORKSHOPS

14
OUTREACH ACTIVITIES

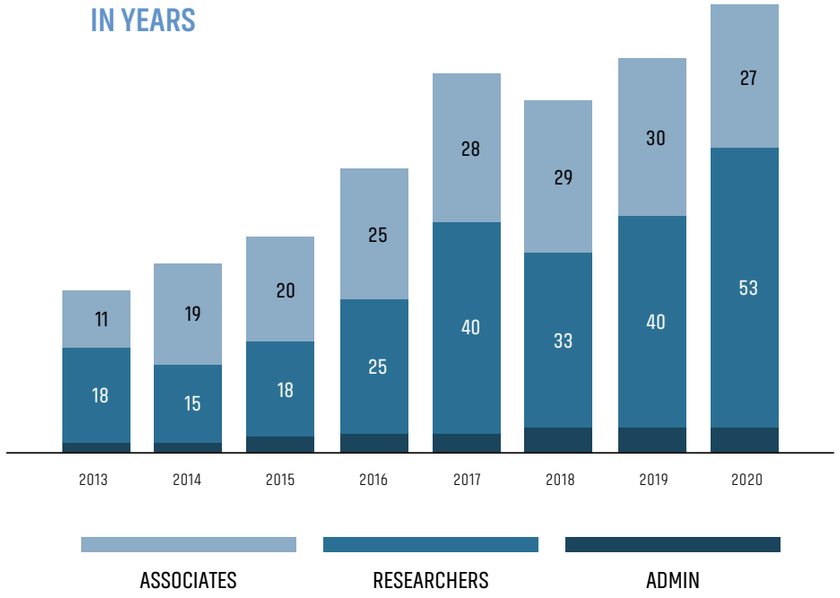
BCMATERIALS
COMMUNITY

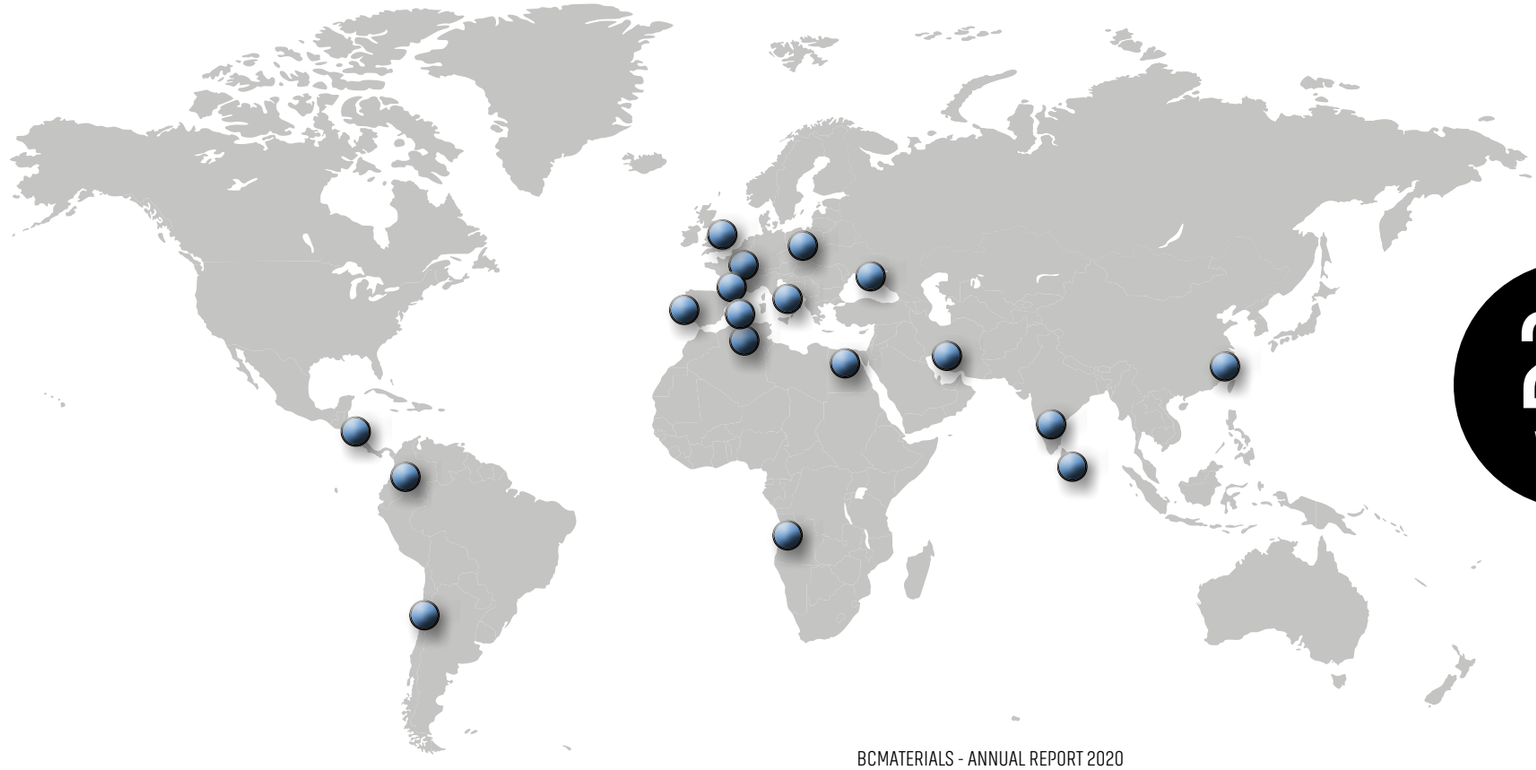


RESEARCH STAFF
NATIONALITY

CHINA	2
COLOMBIA	3
COSTA RICA	1
EGYPT	2
GERMANY	2
INDIA	4
IRAN	1
ITALY	1
CZECHIA	1
PORTUGAL	2
SPAIN	31
SRI LANKA	1
UK	1
UKRAINE	1

RESEARCH COMMUNITY
IN YEARS





28
VISITORS

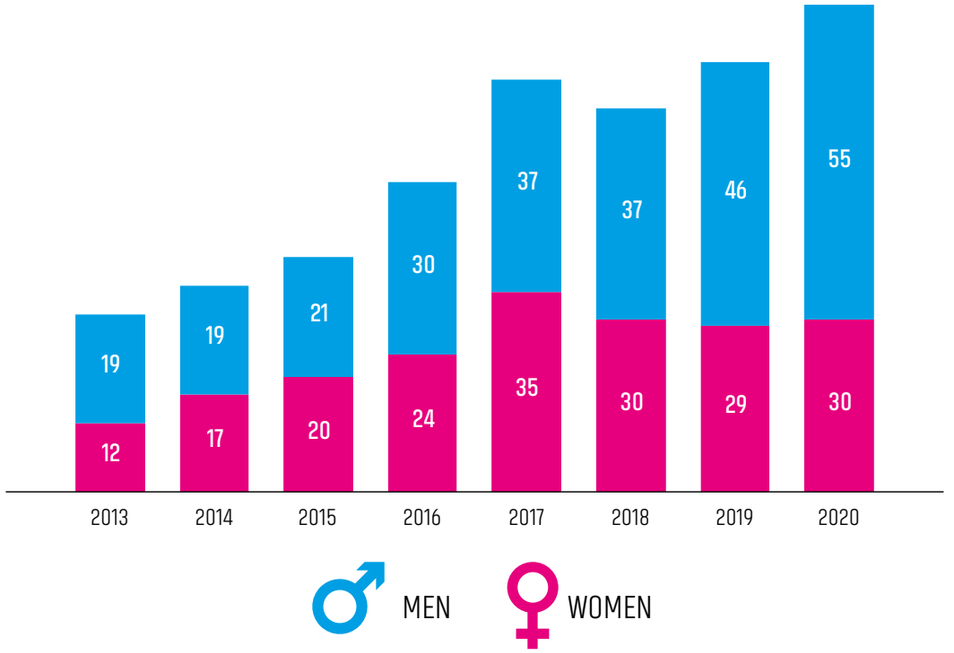
VISITORS
NATIONALITY

1	ANGOLA
1	CHILE
1	CHINA
1	EGYPT
1	FRANCE
1	ITALY
9	PORTUGAL
12	SPAIN
1	TUNISIA

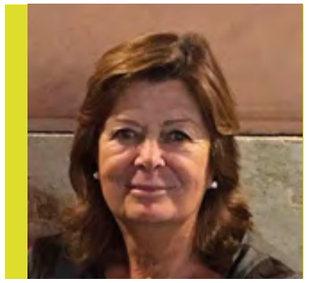
GENDER EQUALITY AT BCMATERIALS

Evolution over the years of gender distribution

Science and technology, truly universal and noble human endeavours, can just achieve their full potential in an environment where excellence and equality are unavoidably put together. BCMaterials continues its effort and commitment with gender equality to achieve materials for a better life ... in a better place.



ADVISORY COMMITTEE



> PROF. MARÍA VALLET-REGÍ

Leader of the Smart Biomaterials Research Group
Group leader of the Biomedical Research Networking Centre in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), and of the Research Institute of the Hospital 12 de Octubre, Madrid. Spain
Dept. of Chemistry in Pharmaceutical Sciences Faculty of Pharmacy, Universidad Complutense Madrid (UCM)

> PROF. CAROLINE A. ROSS

Associate Head of the Department of Materials Science and Engineering
Toyota Professor of Materials Science and Engineering Massachusetts Institute of Technology (MIT), USA

> PROF. SABETH VERPOORTE

Professor of microfluidics and miniaturized “lab-on-a-chip” systems
Faculty of Science and Engineering
University of Groningen, Netherlands

> PROF. GORDON WALLACE

Director ARC Centre of Excellence for Electromaterials Science (ACES)
Director ANFF (Materials Node)
Director Translational Research Initiative for Cellular Engineering and Printing (TRICEP)

> PROF. OMAR M. YAGHI

James and Neeltje Tretter Chair
Professor of Chemistry University of California, Berkeley
Co-Director: Kavli Energy NanoSciences Institute at Berkeley California Research Alliance by BASF

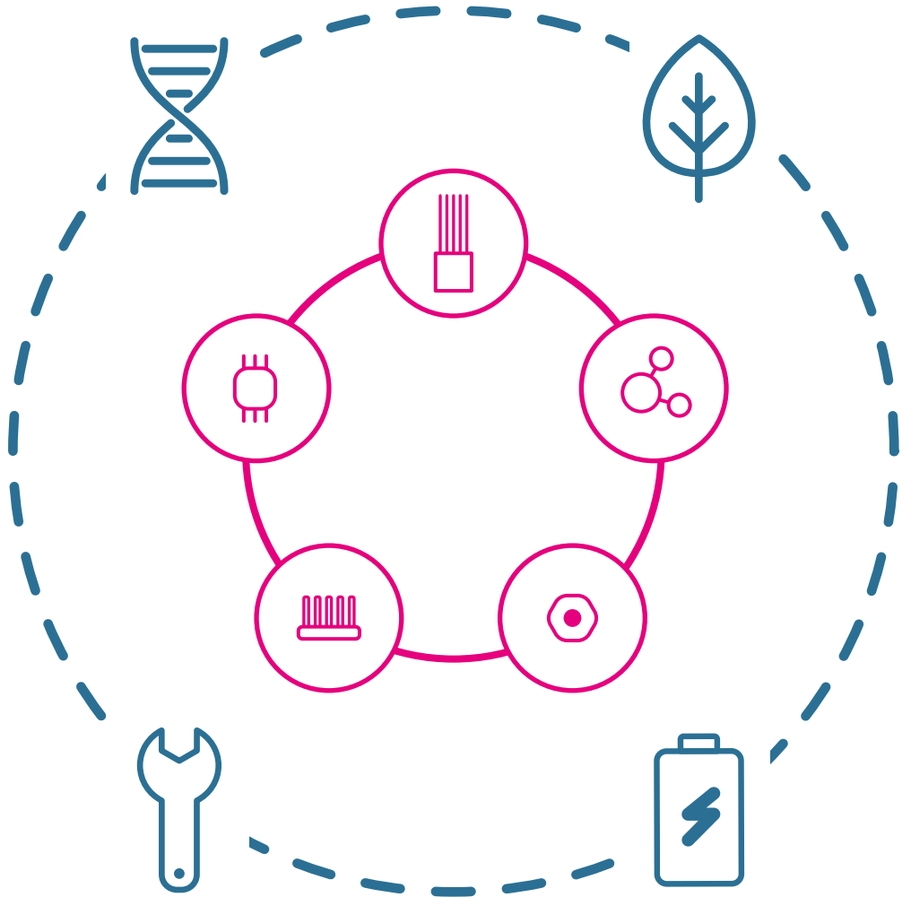
> PROF. PHIL WITHERS FRS FRENG

Regius Professor of Materials at the University of Manchester, UK Chief Scientist of the Henry Royce Institute

RESEARCH AREAS, LINES AND HIGHLIGHTS

BCMaterials has divided its activities into Research lines and Research areas. Research lines are designed to generate knowledge in the new generation of smart, active and multifunctional materials. To achieve excellence in the next generation of materials, to discover materials and effects and to transfer the knowledge to society. Research areas are designed to take advantage to the generated knowledge in advanced materials and to apply them to tackle the most relevant challenges of modern society, ranging from environmental prevention, monitoring and remediation, energy generation and storage, biomedicine and biotechnology as well as to provide the advanced materials required by the digitalization strategies.

“new materials, for a better life”!



AREAS

RESEARCH AREAS ARE DESIGNED TO TAKE ADVANTAGE TO THE GENERATED KNOWLEDGE IN ADVANCED MATERIALS AND TO APPLY THEM TO TACKLE THE MOST RELEVANT CHALLENGES OF MODERN SOCIETY, RANGING FROM ENVIRONMENTAL PREVENTION, MONITORING AND REMEDIATION, ENERGY GENERATION AND STORAGE, BIOMEDICINE AND BIOTECHNOLOGY AS WELL AS TO PROVIDE THE ADVANCED MATERIALS REQUIRED BY THE DIGITALIZATION STRATEGIES.

LINES

RESEARCH LINES ARE DESIGNED TO GENERATE KNOWLEDGE IN THE NEW GENERATION OF SMART, ACTIVE AND MULTIFUNCTIONAL MATERIALS. TO ACHIEVE EXCELLENCE IN THE NEXT GENERATION OF MATERIALS, TO DISCOVER MATERIALS AND EFFECTS AND TO TRANSFER THE KNOWLEDGE TO SOCIETY.WITHIN THE RESEARCH ÁREAS, ONE OR MORE OF THESES RESEARCH LINES WORK TOGETHER IN ORDER TO GIVE ANSWER TO SPECIFIC TECHNOLOGICAL AND SOCIETY CHALLENGES.

ENERGY

One of the grand challenges facing humankind is related to energy. Energy generation and storage are among the key issues of modern society, which is increasingly its generation and storage being among the key issues of modern society, which is increasingly dependent on mobility. BCMaterials specifically focus on the conversion between solar energy, and chemical energy in applications such as perovskite and kesterite based solar cells. We also work on the development of energy harvesting systems, mainly based on mechanoelectric (piezoelectric and triboelectric) and thermo-electric systems for self-powered and wearable sensors. Finally, materials and concepts are being developed for Li and Na batteries, as well as new approaches for solid electrolytes and printable batteries.

ADDITIVE MANUFACTURING

Technological advances often rely on both new materials and processing/manufacturing technologies. Additive manufacturing is undergoing strong developments allowing customized production. Furthermore, conventional manufacturing technologies are being modified to accommodate the concepts of Industry 4.0 and digitalization, as well as to produce advanced materials and solutions in a more environmental friendly and efficient way. BCMaterials is working on the development of smart and multifunctional materials with improved integration through advanced manufacturing processes. Self-sensing, self- cleaning and self-repairing materials are being developed and integrated into functional prototypes, among others.

BIOMEDICINE

Related to the aging of population and the strong needs on early detection of illnesses, advanced biomedical approaches are definitely needed. Advanced multifunctional materials, advanced manufacturing and nanoscience and nanotechnology are providing new tools in order to tackle those important challenges. In this context, BCMaterials is focusing, among others, on the development of materials and new approaches for nanoparticle based biomedicine, from hyperthermia to point of care devices, as well as on the incorporation of active scaffolds and microenvironments for tissue engineering.

ENVIRONMENT

The strong technological advances of recent years are leaving important footprints in our environment. In this scope, three main issues must be solved in the near future: environmental friendlier technologies, sensors for environmental monitoring and remediation of contaminated scenarios. In these areas, BCMaterials is strongly focusing on the development of prevention (environmental friendly materials and processes), monitoring (environmental sensing) and remediation strategies for water and air.

LINE 1:

ACTIVE AND SMART MATERIALS

Coordinator: **Senen Lanceros**

Active and smart materials are at the core of the on-going rapid technological development. Shape memory, magnetocaloric and elastocaloric materials, piezoelectric, magnetoelectric, and self-healing materials as well as multifunctional hydrogels are being developed. A deep understating on the structural and molecular modifications behind the active responses allows tailoring materials responses.

HIGHLIGHT:

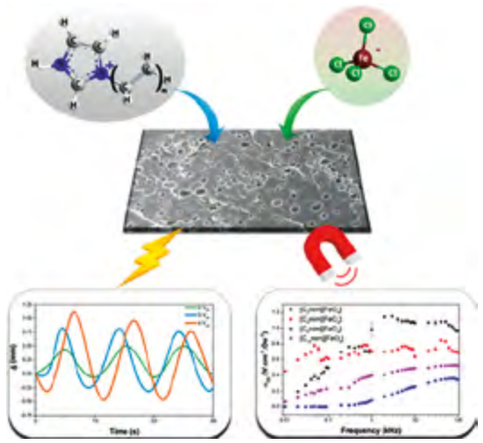
Design of Ionic-Liquid-Based Hybrid Polymer Materials with a Magnetoactive and Electroactive Multifunctional Response

Fernandes, L.C., Correia, D.M., Fernández, E., Esperança, J.M.S.S., Lanceros-Méndez, S.
ACS Applied Materials and Interfaces, 2020, 12(37), pp. 42089–42098

Multifunctional materials with sensor and actuator capabilities play an increasing role in modern technology. In this scope, hybrid materials with magnetic sensing and an electromechanical actuator response based on magnetic ionic liquids (MILs) and the polymer poly(vinylidene fluoride) (PVDF) have been developed being compatible with additive manufacturing technologies

In particular, magnetoelectric (ME) responsive materials have been gaining attention due to their ability to provide coupling between magnetic and dipolar orders, allowing the generation of an electric response upon magnetic stimulation or vice versa. This ME coupling makes them suitable for use in technological applications including transducers, storage devices, sensors, and actuators among others. A step further in the development of magnetoelectrically responsive materials is the introduction of the magnetoionic (MI) effect reported for magnetic ionic liquids (ILs). Due to their interesting and tunable properties, ILs have been attracting strong interest.

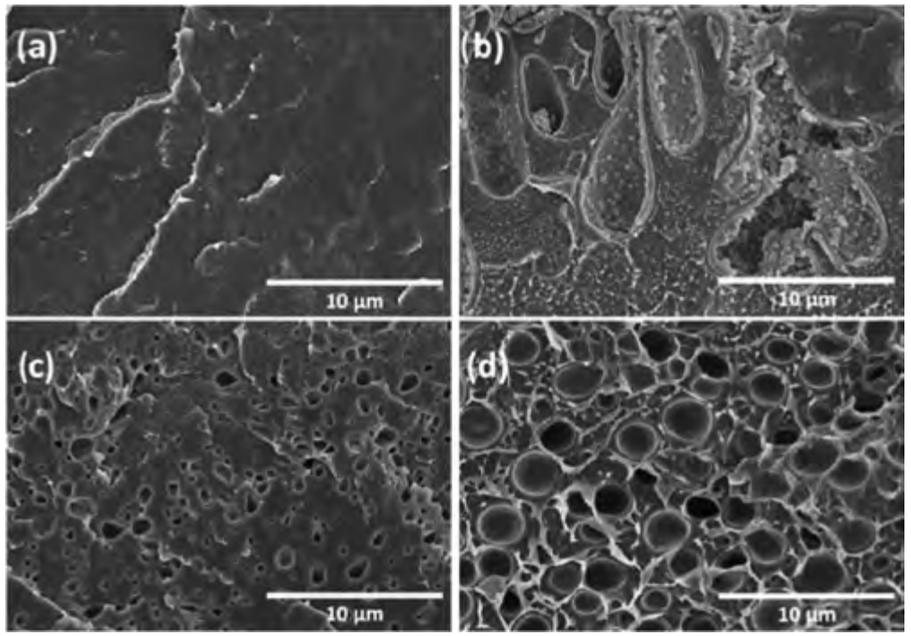
Smart multifunctional materials are capable of adapting to different environments by altering their intrinsic properties in a specific manner when external stimuli are applied, such as stress, temperature, and magnetic and electric fields among others. Recently, important efforts are being carried out to develop smart and multifunctional materials compatible with printing technologies. The combination of both smart materials and printing technologies allows the development of low-cost multifunctional materials with improved integration for practical applications.



Interestingly, IL incorporation into a polymer matrix is one of the most suitable ways to develop high-bending soft actuators, where the electromechanical response is governed by the migration of anions and cations to the electrodes as a result of an applied electric field. Significant efforts are being performed to optimize the maximum bending actuation by varying the polymer matrix, IL type, cations and anions.

It is to be noted that the materials are prepared by solvent casting and therefore their preparation is compatible with additive manufacturing technologies, such as screen or inkjet printing.

Despite the large and increasing interest in IL/polymer composites, no studies have reported the combination of MILs and polymers for actuators. The combination of the two effects (electrical and magnetic) will allow the development of highly interesting hybrid materials with a double functional response, opening new and challenging opportunities in the development of magnetically and electrically responsive soft actuators.



SEM images of the cross section of the MIL/PVDF films with: (a) [C2mim][FeCl4], (b) [C4mim][FeCl4], (c) [C8mim][FeCl4], (d) [C14mim][FeCl4]

HIGHLIGHT:

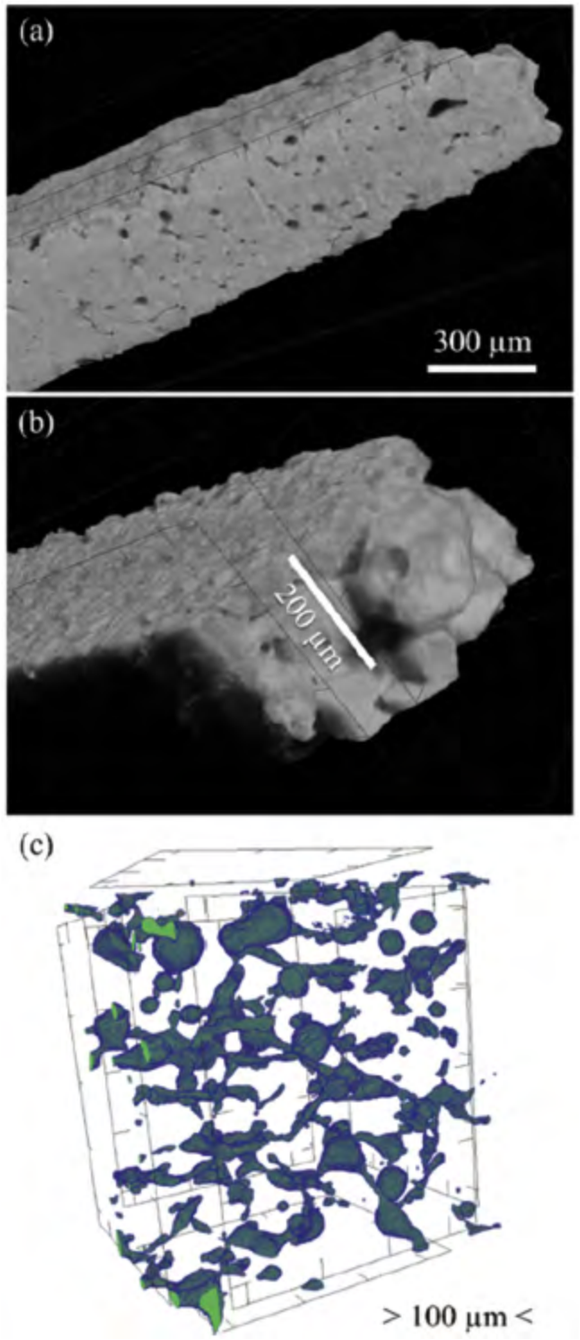
Mastering a 1.2 K hysteresis for martensitic para-ferromagnetic partial transformation in Ni-Mn(Cu)-Ga magnetocaloric material via binder jet 3D printing.

Erica Stevens, Katerina Kimes, Daniel Salazar, Amir Mostafaei, Rafael Rodriguez, Aaron Acierno, Patricia Lazpita, Volodymyr Chernenko, Markus Chmielus.
Additive Manufacturing, 2020, 101560

Worldwide energy consumption is increasing, and a large portion of this growth is generated by cooling technologies such as refrigerators and air conditioners. Recently, the possibility of using solid state magnetic refrigeration, based on the magnetocaloric effect (MCE), has been proposed as an alternative technology. In this study, a Ni49.5Mn19.1Cu6.6Ga24.8 (at.%) alloy is additively manufactured using powder bed binder jet 3D printing with subsequent sintering being proved to be a successful processing route for magnetocaloric materials, such as Ni-Mn-Cu-Ga FSMA

Magnetocaloric (MC) materials have gained traction in the research and industry communities for their prospects in solid state magnetic refrigeration. Important to the commercialization of MC materials are: (1) establishment of a fabrication method that can combine high surface area for heat transfer and geometric freedom for designing an efficient heat exchanger which has low pressure drop for the coolant and (2) advancement of low cost alloys with appropriate MC properties. Magnetic refrigeration presents several advantages compared to the vapor-compression cycle: it can be 20–30 % more efficient than the current technology, it is nearly silent because of the limited need for moving parts like the compressor in a typical system, and it is eco-friendly. Nevertheless, many of the established MCE materials contain rare earth elements, such as Gd and La, which are economically strategic materials, and also present potential health risks to populations near to their mining sites and other occupational exposures.

Numerous sources compiling the current state of magnetocaloric cooling assert the need for a thermally efficient heat exchanger that has a high surface-to-volume ratio, in order to maximize heat transfer capabilities. Such a heat exchanger is a challenge when fabrication or assembly techniques affect materials' functionality, leaving some alloys that show promise in laboratory testing to exhibit only a modest MCE after fabrication



3D visualizations using data collected by µCT. (a) The view of a cut side of the slice, (b) a single grain on the top of the slice, (c) porosity only, visualized for a small cube of volume.

The present study explores a magnetocaloric material fabricated via binder jet 3D printing (BJ3DP), focusing on the Ni-Mn(Cu)-Ga FSMA, transforming martensitically near room temperature from the paramagnetic austenite into the ferromagnetic martensite.

We found that the MT in this material can be realized with an extremely narrow thermal hysteresis of 1.2 K through a partial transformation still involving large values of ΔM, ΔSm and ΔTad. The relatively small values of both hysteresis and transformation interval gave rise to the stable cycling amplitude of ΔTad equal to about 2 K under 2 T at 304 K.

LINE 2:

ADVANCED MATERIALS

Coordinator: **Shahzada Ahmad**

This research line concerns mainly on the implementation through deep fundamental understanding of functional materials for advanced technological needs. Functional materials are of critical importance in materials for energy such as electro- and magnetocaloric materials, for energy storage and for solar harvesting functions. In this regard, BCMaterials covers the synthesis, development and scale-up of a wide range of materials for fuel cells and batteries, photovoltaic materials, permanent magnets, sensors and biosensors. Membranes technologies for environmental monitoring and remediation are also being developed to address relevant society concerns.

HIGHLIGHT:

Reduced trap density and mitigating the interfacial losses by placing 2D dichalcogenide material at perovskite/HTM interface in a dopant free perovskite solar cells.

Hemasiri, N.H., Kazim, S., Ahmad, S.
Nano Energy, 2020, 77, 105292

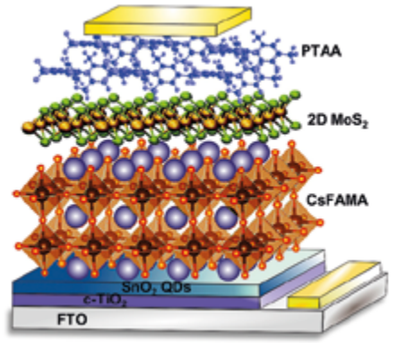
Solution-processed photovoltaics employing perovskite as light harvester are the next generation future energy source owing to its low manufacturing cost and potential to achieve high power conversion efficiency. Significant emphasis has been laid on the performance-related investigations, however the long-term instability under operational conditions and device reproducibility obstruct its potential commercial endeavour.

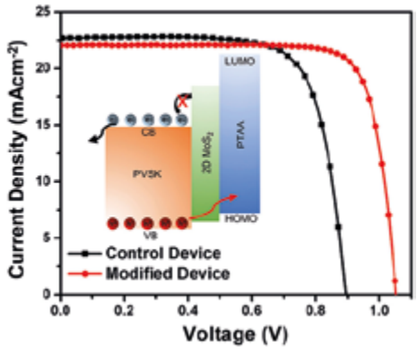
Herein, by tweaking the energy level alignment between the hole-transport layer and perovskite, by the placement of a 2D-MoS2 interlayer, we demonstrate suppressed interfacial charge accumulation, fast charge extraction, and subsequently improved photovoltaic performances.

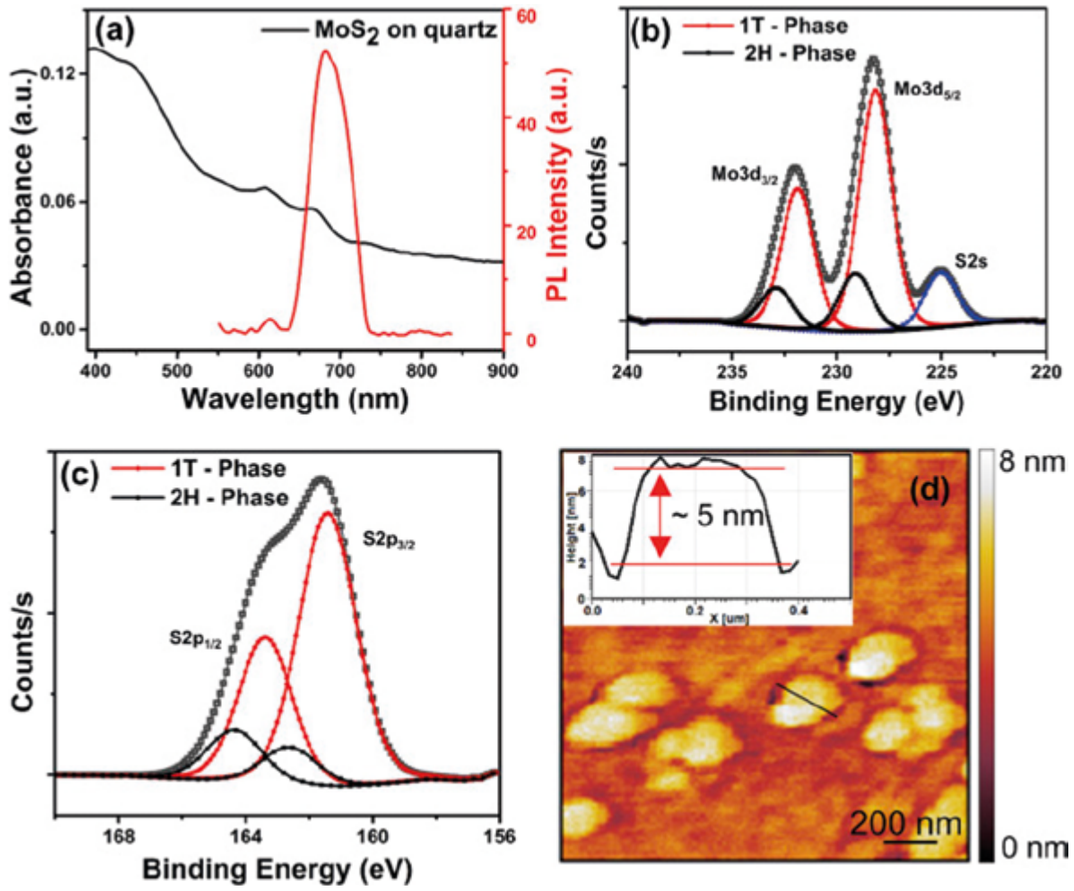
Notably, with the usage of a dopant free hole transport materials, a power conversion efficiency of 18.54% with significantly upgraded open circuit voltage (Voc) and FF was recorded. The stability measurement shows that the resulting 2D-MoS2 supported dopant-free hole selective layers exhibit notable moisture stability under ambient conditions. Our study put forward the profound experimental understanding of 2D-transition metal dichalcogenides as an agent to engineering the interface, enlightening the power conversion efficiency and lifetime of the perovskite solar cells.

In the present work, we demonstrate the use of intercalated Li+ based solution-processable 2D-MoS2 flakes as hole extraction interlayer in n-i-p type PSCs using triple-cation perovskite [Cs0.1FAPbI3(0.81) MAPbBr3(0.09)] and dopant-free PTAA to improve optoelectronic properties and operation stability.

The fabricated device gave an improved PCE of 18.54% and lifetime as compared to the controlled device without MoS2 interlayer (15.05% PCE). The improvement is ascribed to the efficient hole extraction with the stabilization of the perovskite/HTM interface, band alignment and mitigating the degradation in the active layer.







UV-Vis absorbance and photoluminescence spectra of spin coated 2D-MoS2 on quartz substrate. XPS narrow spectrum of (b) Mo3d and (c) S2p of spin coated MoS2 thin film and (d) topography of drop casted MoS2 thin film on Si substrate, inset shows the thickness profile.

HIGHLIGHT:

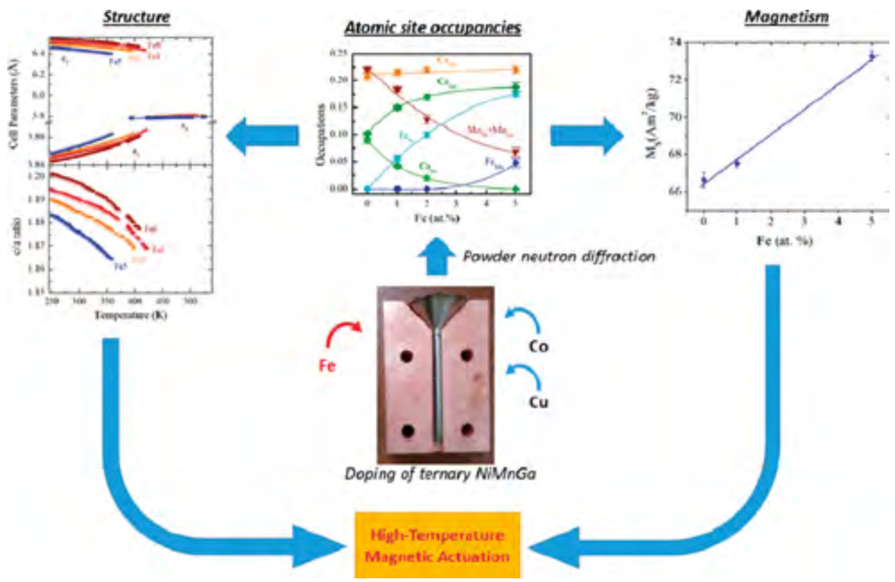
Role of Fe addition in Ni–Mn–Ga–Co–Cu–Fe ferromagnetic shape memory alloys for high-temperature magnetic actuation

Anabel Pérez-Checa, Jose M.Porro, Jorge Feuchtwanger, Patricia Lázpita, Thomas C.; Mondelli, Claudia; Sozinov, Alexei; Barandiarán, Jose M.; Ullakko, Kari; Chemenko, Volodymyr.
Acta Materialia, 2020, 196, pp. 549–555

The Ni–Mn–Ga ferromagnetic shape memory alloys (FSMAs) are a group of active materials that undergo martensitic transformations (MTs) induced by temperature, stress and/or magnetic fields, resulting in large recoverable mechanical deformations. Their fast response and high energy density make them ideal candidates for implementation in sensors and actuators.

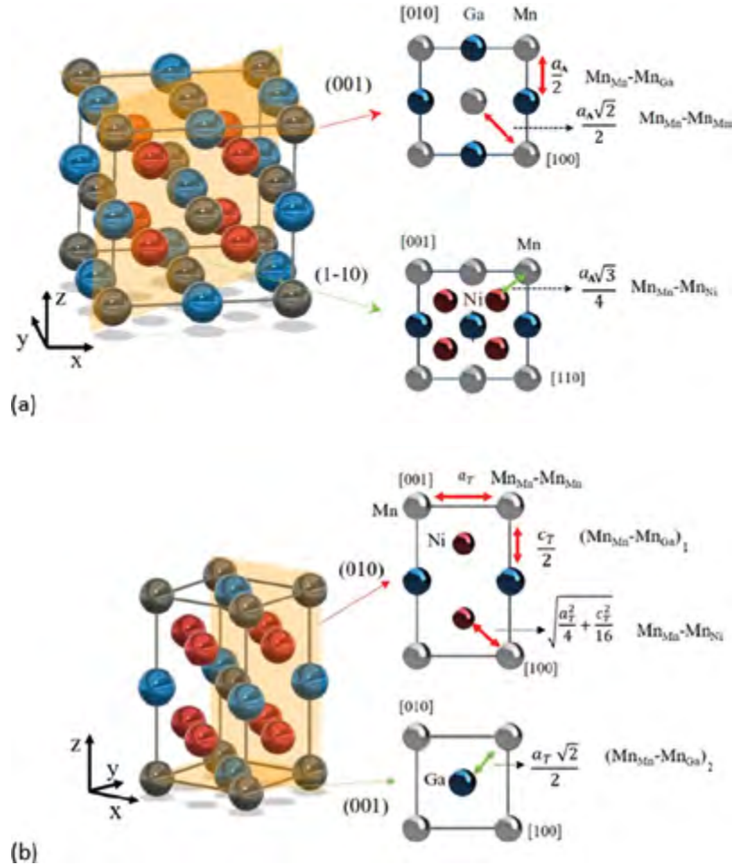
Here we investigate a series of the polycrystalline Ni45Mn25-xGa20Co5Cu5Fex (x = 0, 1, 2 and 5 at%) HTFSMAs. Their MT and Curie temperatures, the crystal structures of the martensitic and austenitic phases, the temperature evolutions of the lattice parameters of both phases and the atomic site occupancies have been studied by means of powder neutron diffraction measurements, complemented by standard characterization techniques.

The development of high-temperature FSMAs (HTFSMAs), capable of working at temperatures over 373 K, has recently become a challenging task to meet the current requirements of modern technologies, especially those used in the automotive industry.



Neutron diffraction is a particularly relevant method to elucidate the nature of magnetism and its interplay with the crystal structure in FSMAs. Indeed, neutron diffraction demonstrated to be a fruitful method to probe the influence of the atomic site occupancies and/or structural changes during MTs on the magnetic properties of Ni–Mn–Ga-based FSMAs.

Here we report on the influence of the structure and atomic site occupancies on the magnetic properties of the Ni45Mn25-xGa20Co5Cu5Fex (x = 0, 1, 2 and 5 at%) alloys series studied by powder neutron diffraction. This alloy system was selected as a good candidate to present a high temperature magnetic actuation since, e.g., the bulk polycrystalline alloy Fe5 from this series demonstrated the promising characteristics, such as TM = 370 K, TC = 440 K and c/a ≈ 1.16 in the vicinity of MT



(a) The austenitic L21 cubic structure for off-stoichiometric ternary Ni–Mn–Ga. Red, gray and blue positions correspond to 8c, 4a and 4b atomic sites, respectively, following the Wyckoff nomenclature. Insets represent (001) and (1–10) planes, shaded in yellow in the 3D unit cell, showing the interatomic distances between the different atomic positions occupied by the Mn atoms.

(b) The martensitic tetragonal structure for off-stoichiometric ternary Ni–Mn–Ga. Red, gray and blue positions correspond to 4d, 2a and 2b atomic sites, respectively.

LINE 3:

FUNCTIONAL SURFACES & COATINGS

Coordinator: **Senen Lanceros**

Surface properties present relevant and specific scientific challenges that must be understood in depth prior to their implementation in devices. Paving the way towards a systematic functionalization of surfaces of active materials, via patterning and/or chemical modification techniques, will lead to obtaining specific and tailored magnetic, optical and mechanical responses in these materials upon the application of the pertinent stimulus. In this context, BCMaterials is working on the investigation of patterned surfaces and films and well as on the functional surface modification following a wide variety of methods, including chemical and physical deposition and printing techniques, among others.

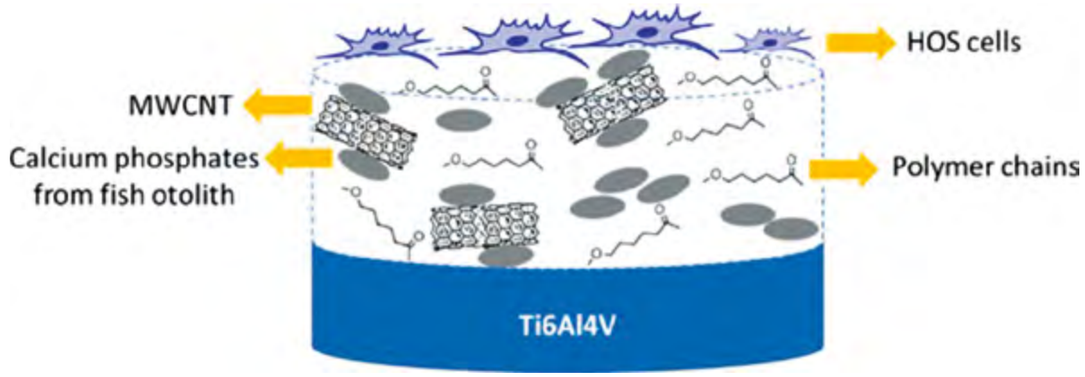
HIGHLIGHT:

Functional evaluation and testing of a newly developed Teleost's Fish Otolith derived biocomposite coating for healthcare.

Nerly D. Montañez, Heider Carreño, Patricia Escobar, Hugo A. Estupiñán, Darío Y. Peña, Saurav Goel & Jose L. Endrino
Scientific Reports, 2020, 10(1), 258

Metallic biomaterials used in implantology are usually inert, since there is no ion active exchange. This property allows the cells to recognize the microenvironment, proliferate and differentiate in a better way. For this reason, biocompatible materials in coatings such as polycaprolactone (PCL) allows easy incorporation of bioactive materials or active ingredients making the recovery of hard tissue faster.

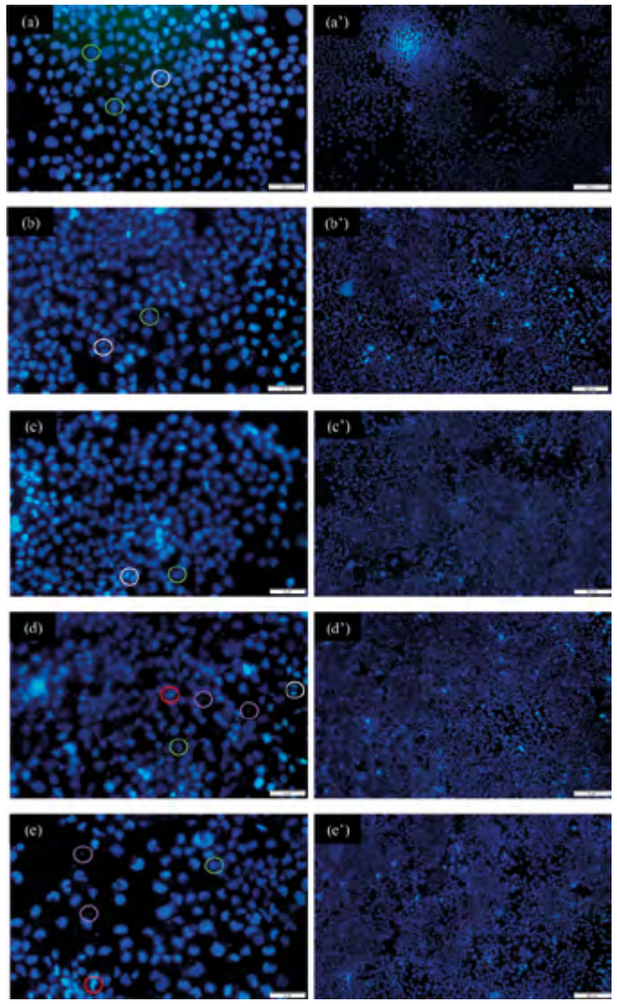
Polymers such as PCL possess biodegradability, biocompatibility and affinity with other organic media that makes them suitable for biomedical applications. In this work, a novel biocomposite coating was synthesised by mixing PCL with layers of calcium phosphate (hydroxyapatite, brushite and monetite) from a biomineral called otolith extracted from Teleost fish (Plagioscion Squamosissimus) and multiwalled carbon nanotubes in different concentrations (0.5, 1.0 and 1.5 g/L).



Multiwalled carbon nanotubes functionalized with CP in a PCL polymer matrix coating.

It was found that an increase in the concentration of carbon nanotube induced microstructural phase changes of calcium phosphate (CP) leading to the formation of brushite, monetite and hydroxyapatite. While we discovered that an increase in the concentration of carbon nanotube generally improves the adhesion of the coating with the substrate, a certain threshold exists such that the best deposition surfaces were obtained as PCL/CP/CNT 0.0 g/L and PCL/CP/CNT 0.5 g/L.

It was concluded from the overall results that the newly developed biocoating composed of polycaprolactone, calcium phosphates from otolith and carbon nanotubes in low concentrations, is a potentially future material for use in regeneration and treatment of bone.



Fluorescence micrographs of polycaprolactone-MWCNT/CP coatings (a,a') control, (b,b') 0.0 g/L CNT, (c,c') 0.5 g/L CNT, (d,d') 1.0 g/L CNT and (e,e') 1.5 g/L CNT. The original magnification was 40X for (a–e) and 10X for (a'–e'). Scale bar = 50 μm for (a–e) and scale bar = 200 μm for (a'–e').

White circles: mitotic cells, green circles: flattened live cells, red circles: early apoptosis, purple circles: micronucleus.

HIGHLIGHT:

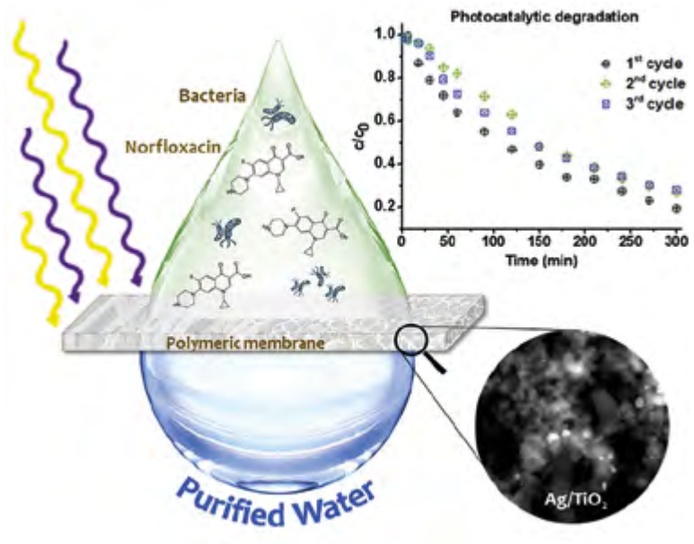
Photocatalytic and antimicrobial multifunctional nanocomposite membranes for emerging pollutants water treatment applications.

H Salazar, P M Martins, Bruno Santos, M M Fernandes, Ander Reizabal, Víctor Sebastián, G Botelho, Carlos J Tavares, José L Vilas-Vilela, S Lanceros-Mendez.
Chemosphere Volume 250, July 2020.

Emerging pollutants represent a new global problem for water quality. As these compounds get into the environment, they cause severe threats to aquatic environments and human health and are typically resistant to conventional wastewater treatments. In this work, TiO2 nanoparticles surface was functionalized with silver (Ag) nanoparticles, and solvent cast and electrospun membranes of poly (vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) were prepared with different concentrations of TiO2 and Ag–TiO2 to produce a multifunctional material.

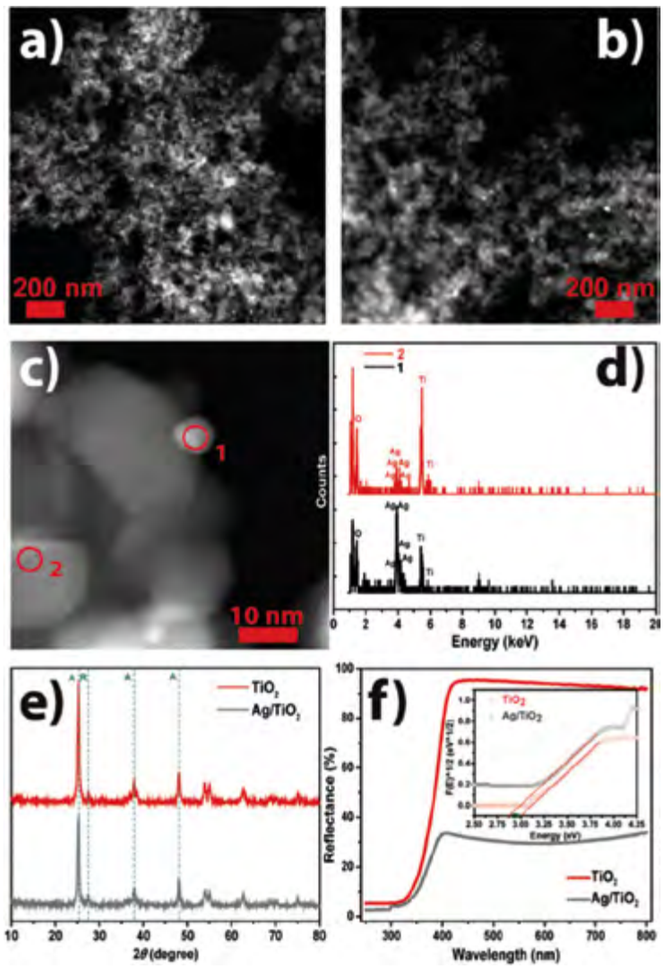
It is shown the antimicrobial activity of the nanocomposite membranes, demonstrating the suitability of the Ag-TiO2/PVDF-HFP nanocomposites as multifunctional photocatalytic and antimicrobial membranes for water remediation applications.

Poly (vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) is a copolymer of poly (vinylidene fluoride) (PVDF) widely used as membrane material, mainly because of their high mechanical, chemical, thermal, and UV stability. Another relevant feature of the PVDF polymer family is the easy processability, allowing the production of materials with different morphologies (e.g. thin films, porous membranes, and fibre mats) that may also influence their photocatalytic efficiency.



The prevention of the PVDF-HFP membranes fouling will be played by the presence of silver nanoparticles in the Ag-TiO2 nanocomposite, based on the antimicrobial properties of Ag nanoparticles. Silver ions released by the silver nanoparticles cease the activity of bacteria attached to the membrane surface, thus preventing its adherence and penetration in the inner structure of the membrane during the water remediation processes.

Therefore, the combination of the properties of the Ag functionalized TiO2 nanoparticles, and the PVDF-HFP matrix is a novel composite material that allows the development of multifunctional membranes suitable for wastewater treatments. Thus, this work will focus on the evaluation of the multifunctional properties of the Ag-TiO2/PVDF-HFP nanocomposite membrane, including the photocatalytic and antimicrobial properties as well as the reuse of the polymeric nanocomposites.



The STEM-HAADF micrographs of the Ag-TiO2 nanocomposite a) and b). The STEM-HAADF-EDX image of Ag-TiO2 nanocomposites with the representation of the measured points: Ag (1) and TiO2 (2) c); EDX spectra with elemental identification (Ag, Ti, O, and C) for points 1 and 2 d); X-ray diffraction patterns of pristine TiO2 and Ag-TiO2 nanocomposite and identification of the representative peaks for anatase (A) and rutile (R) phases e); UV-vis reflectance spectra of pristine TiO2 and Ag-TiO2 f). The inset shows the estimation of the bandgap for both samples at [F(R)]1/2 = 0.

LINE 4:

MICRO & NANO DEVICES

Coordinator: **Javier del Campo**

The multifunctional materials, nanostructures and surfaces being developed are implemented in functional prototypes demonstrating the suitability of the materials for advanced applications. Thus, radiofrequency instrumentation is being implemented for MRI, hyperthermia, and wideband ferromagnetic resonance applications. Force, deformation, magnetic, magnetostrictive and chemical sensors are being produced. In addition, the study and implementation of printed and flexible electronic devices is being used for applications in areas such as wearables, point of care devices, interactive surfaces and structural health monitoring.

HIGHLIGHT:

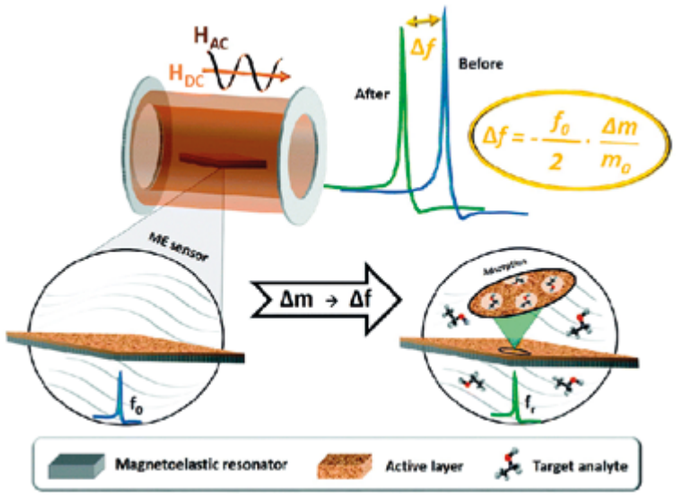
Rhombic-magnetoelastic/metal-organic framework functionalized resonators for highly sensitive toluene detection

Paula G. Saiz, Roberto Fernández de Luis, Luis Bartolome, Jon Gutiérrez, María Isabel Arriortua and Ana Catarina Lopes
Journal of Materials Chemistry C, 2020, 8(39), pp. 13743–13753

The monitoring of different harmful gases such as volatile organic compounds (VOCs) is essential to ensure the air quality and population security. Therefore, the development of rapid, cheap and accurate sensing devices is a key to enable continuous monitoring of the air quality. On this matter, magnetoelastic sensors, particularly the rhombus-shaped ones, have become an interesting alternative to the current sensing systems because, besides exhibiting a fast response, they present a wireless sensing capacity. Moreover, the addition of metal–organic frameworks (MOFs) as highly porous active layers to different sensing devices endows them with the desired adsorption capacity and selectivity to detect VOCs.

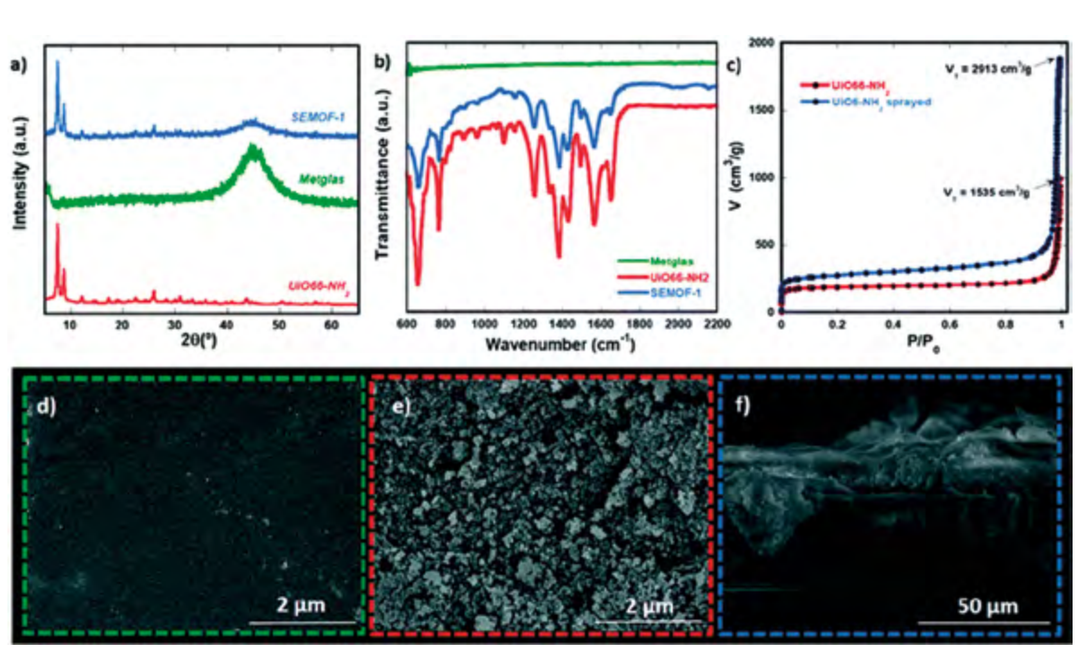
In this work, we explore the performance of a highly sensitive rhombic magnetoelastic Metglas 2826 MB resonator functionalized with a high-toluene adsorption capacity MOF layer (i.e. Ui066-NH2) for its wireless detection. Our findings confirm the feasibility of the Metglas/MOF system for fast and reversible toluene detection, being key the control of the active layer mass to improve its sensitivity.

From the toluene sensing experiments, a maximum sensitivity of 0.27 Hz ppm−1 was determined. Finally, the sensor selectivity has been evaluated through the analysis of the sensor response to different atmospheres (water, acetone, ethanol and toluene) and it was observed that the sensor presents an enhanced selectivity towards toluene.



The sensitivity of the fabricated sensor is dependent on the toluene flow concentration and on the MOF active layer mass. Specifically, the maximum sensitivity values for SEMOF-1 (0.19 Hz ppm−1) and SEMOF-2 (0.27 Hz ppm−1) can be further improved by increasing the active layer mass. In addition, both sensors exhibit repeatable and stable cyclability, as has been confirmed from the adsorption–desorption cycling experiments. Finally, an enhanced selectivity towards toluene has been observed when compared with other gases such acetone, ethanol and water. Nevertheless, the sensor also presents a significant response to water, and thus, further modification of the MOF active layer itself should be explored in the future to endow it with an hydrophobic character that hinders water adsorption from the surrounding.

This initial proof-of-concept study confirms the high toluene sensitivity and the resonance peak quality of the Metglas/Ui066-NH2 system, opening the possibility of further tuning or modification of the magnetoelastic sensor response, not only for their application in VOC detection, but also in many other scenarios where the monitoring of hazardous substances is necessary.



a) XRD patterns and (b) FTIR-ATR spectra of the MOF, the bare Metglas resonator and the SEMOF-1 sensor, (c) N2 adsorption isotherm measured for Ui066-NH2 and Ui066-NH2 sprayed and (d–f) SEM images of the: (d) bare resonator surface, (e) MOF layer deposited on the sensor surface and (f) cross-sectional view of the SEMOF-1 functionalized sensor.

HIGHLIGHT:

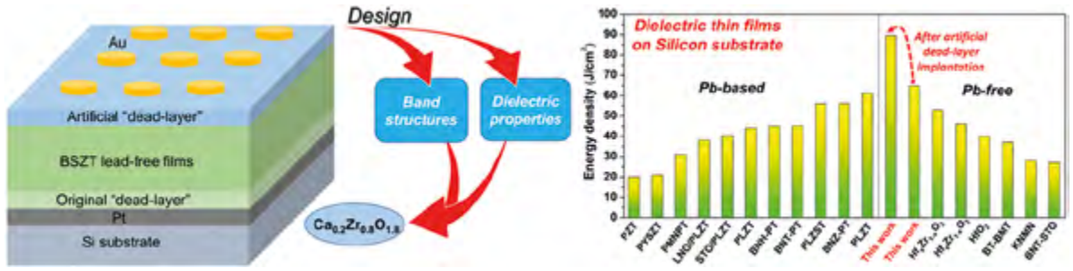
Giant energy storage density in lead-free dielectric thin films deposited on Si wafers with an artificial dead-layer

Xiaoyang Chen; Biaolin Peng; Mingjian Ding; Xiaoshan Zhang; Bin Xie; Taolan Mo; Qi Zhang; Ping Yu; Zhong Lin Wang
Nano Energy, 2020, 78, 105390

High-performance lead-free thin-film capacitors deposited on the silicon (Si) wafers with large energy storage density (W) and high reliability are strongly attractive in the modern electrical and electronic devices. Here, an ultrahigh W was achieved in the Ba0.3Sr0.7Zr0.18Ti0.8203 (BSZT) relaxor ferroelectric thin films deposited on the Si wafers with the help of an ultrathin Ca0.2Zr0.801.8 (CSZ) artificial “dead-layer” simultaneously possessing high resistivity, wide band gap and high permittivity among linear dielectrics.

As the CSZ was implanted, the W of the Ba0.3Sr0.7Zr0.18Ti0.8203 (BSZT) thin films was greatly increased from 64.9 J/cm3 to 89.4 J/cm3, which is comparable to the best W of thin film deposited on expensive single crystal substrates, and is the largest one reported so far than those of lead-free thin films deposited on the Si wafers, and even for lead thin films.

Due to the formation of ultrahigh electrons injection barrier (3.92 eV) between the interface of the CSZ dead layer and the Au top electrode, the Schottky emission of the BSZT thin films under high electric field and at high temperatures was effective suppressed, which is responsible for the greatly improved dielectric breakdown strength and thermal stability. Moreover, the fatigue endurance was also enhanced.

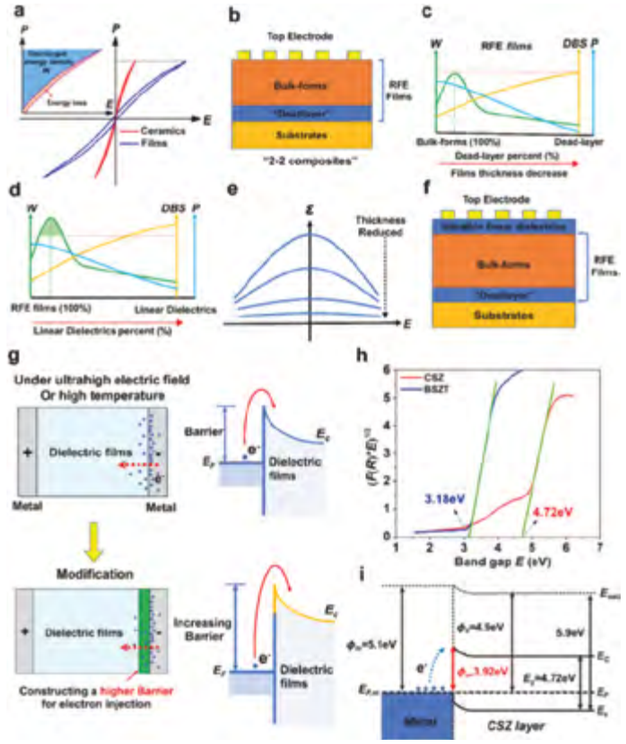


With the help of an ultrathin Ca0.2Zr0.801.8 artificial “dead-layer”, the energy storage properties of the BSZT thin films was greatly improved. The implantation of the new artificial dead-layer could be used as a universal-simple-effective strategy to improve the electrical performances of ferroelectric materials working in the high electric field.

In this paper, Ba0.3Sr0.7Zr0.18Ti0.8203 thin films were fabricated on the Pt coated Si wafers by radio-frequency (RF) magnetron sputtering. In order to obtain higher DBS and W, an artificial “dead-layer” composed of the Ca0.2Zr0.801.8 (CSZ) linear dielectric material was inserted between Ba0.3Sr0.7Zr0.18Ti0.8203 and top Au electrode to limit the infusion of space charge from the Au electrode into Ba0.3Sr0.7Zr0.18Ti0.8203 thin film under high electric field.

It is concluded that the implantation of the CSZ artificial dead-layer could be used as a universal-simple-effective strategy to improve the electrical performances of ferroelectric materials working in the harsh environment of high electric field.

After this interface modulation, the dielectric properties, electric breakdown strength and energy storage characteristics as a function of electric field, temperature and fatigue endurance, were investigated. For a more insightful understanding of this modulation, we conducted measurements and analysis of the leakage current mechanism of Pt/BSZT/Au and Pt/BSZT/CSZ/Au films, respectively.



Artificial dead-layer design and analysis. (a) a comparison in the P-E loops between RFE films and ceramics, a schematic illustration of the energy storage in RFE (inset); (b) a schematic illustration of the dead-layer model by using 2-2 composites; (c) the energy density W, DBS and P of the RFE films as a function of the dead-layer content by treating RFE films as a 2-2 composites; (d) the energy density W, DBS and P of the 2-2 composite films (RFE films/artificial dead-layer) as a function of the artificial dead-layer content; (e) Dielectric constant ε_r as function of the DC electric field for different RFE film thicknesses; (f) a schematic illustration of the artificial dead-layer model; (g) the dielectrics/electrode interface design for supressing the electron injection. (h) the bandgap of CSZ and BSZT; (i) the band diagrams at the Au/CSZ interface, EF Fermi level, Eg bandgap, Ec conduction band, Ev valence band, Evac the vacuum energy level, φd work function of CSZ, φm work function of Au, φe potential barrier for electrons injection.

LINE 5:

NANOSTRUCTURED MATERIALS

Coordinator: Stefan Wuttke

Nanostructures are being developed in order to take advantage of their specifically tailored properties and to make use of them in the development of multiresponsive composites. Magnetic nanoparticles produced by bacteria are being investigated, together with novel magnetic, plasmonic and photocatalytic nanoparticles, among others. Further, novel porous materials, basically MOFS and Zeolites are being investigated based on their tuneability and outstanding intrinsic properties.

HIGHLIGHT:

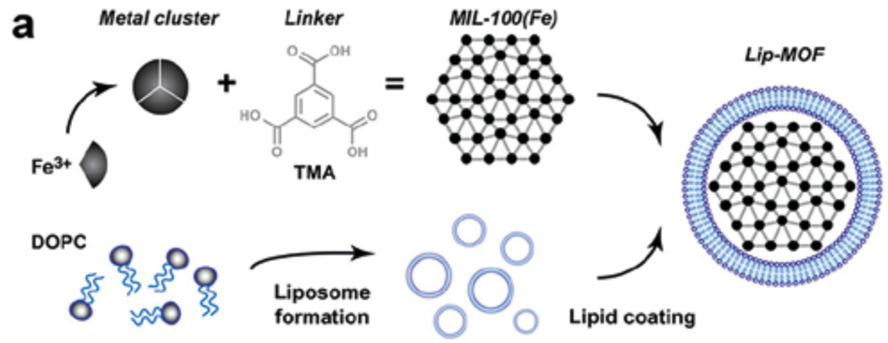
Metal–Organic Framework Nanoparticles Induce Pyroptosis in Cells Controlled by the Extracellular pH.

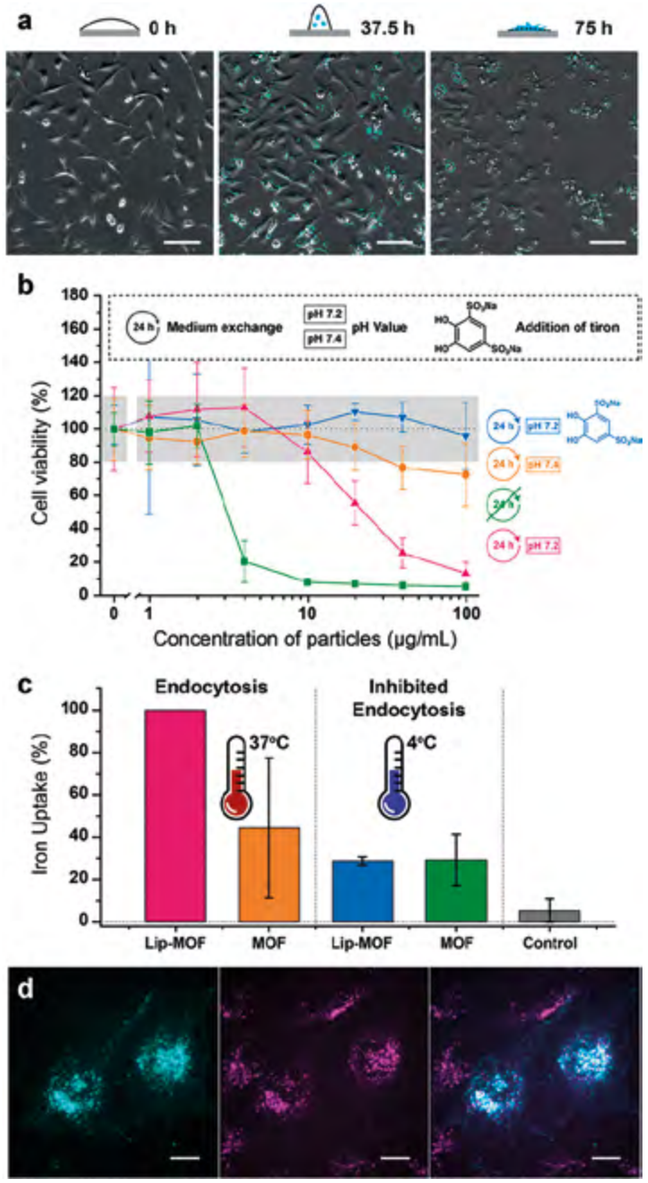
Evelyn Ploetz, Andreas Zimpel , Valentina Cauda , David Bauer , Don C Lamb, Christoph Haisch , Stefan Zahler , Angelika M Vollmar , Stefan Wuttke , Hanna Engelke
Advanced Materials, 2020, 32(19), 1907267

Ion homeostasis is essential for cellular survival, and elevated concentrations of specific ions are used to start distinct forms of programmed cell death. However, investigating the influence of certain ions on cells in a controlled way has been hampered due to the tight regulation of ion import by cells.
A new functionality of hybrid nanoparticles is demonstrated, which uses their nanoarchitecture to facilitate controlled ion delivery into cells. Based on the selectivity for acidic microenvironments, the described nanoparticles may also be used for immunotherapy: the nanoparticles may directly affect the primary tumor and the induced pyroptosis activates the immune system.

In this study, we show that lipid-coated MIL-100(Fe) MOF nanoparticles, consisting of iron (Fe3+) and trimesic acid, are able to introduce high amounts of iron ions into cells. The lipid coating facilitates cellular uptake via endocytosis. Acidification of the extracellular pH subsequently leads to intracellular degradation of MOF nanoparticles and release of iron followed by cell death and lysis.

When studying this process in detail, we found that degradation of MOF nanoparticles triggers pyroptosis, an inflammatory form of programmed cell death.[11] Its dependence on the extracellular pH provides an external trigger for pyroptosis induction. This shows how delivery of ion overdoses can lead to unforeseen effects, such as the activation of pyroptosis in this particular case. Similar effects may be found when the principle of ion delivery via controlled degradation of lipid-coated MOF nanoparticles is applied to other ions.





Uptake and cell viability of Lip-MOF in cells. a) Time-lapse images of Lip-MOF on HeLa cells. Overlay of bright-field (grayscale) and fluorescence (cyan) images at 0, 37.5, and 75 h after incubation of HeLa cells with calcein-loaded Lip-MOF. Over time, Lip-MOF degrade as visualized by the increase in calcein fluorescence (cyan). Subsequently, cell lysis is observed. A schematic representation of cell shape at the respective time points is shown on top of each image. Scale bar: 100 µm. b) Cell viability after Lip-MOF incubation for 72 h measured via a MTT assay. Incubation without medium exchange (green squares) leads to cell death. Medium exchange to pH 7.4 (orange circles) every 24 h restores cell viability. Medium exchange to pH 7.2 (red triangles) every 24 h did not prevent cell death. Addition of the iron-chelating compound Tiron (blue triangles) after 24 h restores cell viability. The mean values and standard deviations represent the average of biological triplicates. Each data set is normalized to cells growing under the same conditions but without exposure to Lip-MOF. The gray background is a guide to the eye indicating no significant toxicity. c) Iron uptake of HeLa cells measured by ICP-OES after incubation of Lip-MOF and uncoated MOF nanoparticles at 37 and 4 °C. Values are normalized to iron uptake for Lip-MOF at 37 °C. The negative control is without MOF addition. d) Confocal microscopy images of HeLa cells incubated with Atto647N-loaded Lip-MOF after 40 h incubation without medium exchange. Lysosomes (cyan) and nanoparticles (magenta) are colocalized as shown in white in the merged image on the right. Lysosomes were labeled by transiently transfecting the cells with CellLight Lysosomes-GFP. Scale bar: 25 µm.

HIGHLIGHT:

Fullerenes as an Effective Amyloid Fibrils Disaggregating Nanomaterial. ACS Applied Materials and Interfaces, 2020, 12(29), pp. 32410–32419

Katarina Siposova, Viktor I Petrenko, Oleksandr I Ivankov, Andrey Musatov, Leonid A Bulavin, Mikhail V Avdeev, Olena A Kyzyma

ACS Applied Materials and Interfaces, 2020, 12(29), pp. 32410–32419

Nowadays, determining the disassembly mechanism of amyloids under nanomaterials action is a crucial issue for their successful future use in therapy of neurodegenerative and overall amyloid-related diseases. In this study, the antiamyloid disassembly activity of fullerenes C60 and C70 dispersed in 1-methyl-2-pyrrolidinone (NMP) toward amyloid fibrils preformed from lysozyme and insulin was investigated using a combination of different experimental techniques.

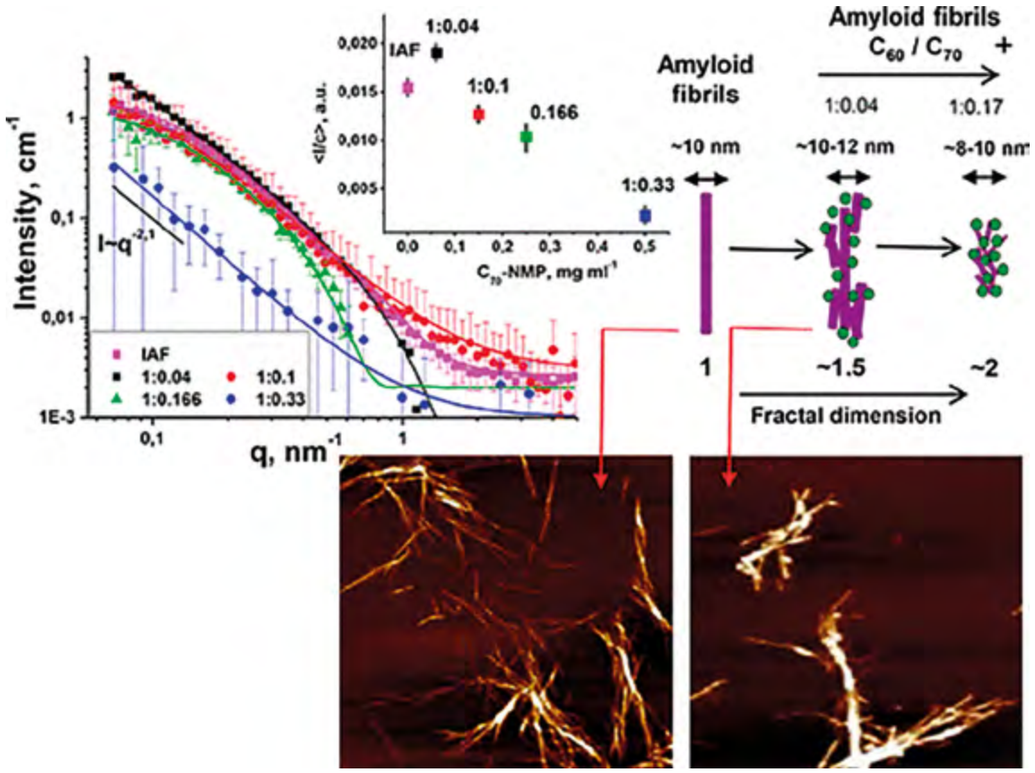
Poly (vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) is a copolymer of poly (vinylidene fluoride) (PVDF) widely used as membrane material, Thioflavin T fluorescence assay and atomic force microscopy were applied for monitoring of disaggregation activity of fullerenes.

It was demonstrated that both types of fullerene-based complexes are very effective in disassembling preformed fibrils, and characterized by the low apparent half-maximal disaggregation concentration (DC50) in the range of ~22–30 µg mL-1. Small-angle neutron scattering was employed to monitor the different stages of the disassembly process with respect to the size and morphology of the aggregates. Based on the obtained results, a possible disassembly mechanism for amyloid fibrils interacting with fullerene/NMP complexes was proposed. The study is a principal step in understanding of the fullerenes destruction mechanism of the protein amyloids, as well as providing valuable information on how macromolecules can be engineered to disassemble unwanted amyloid aggregates by different mechanisms.

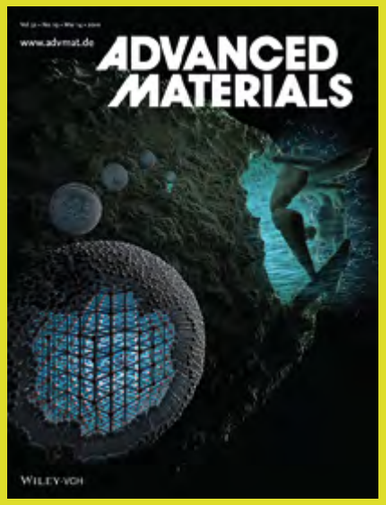
The aim of the work was 2-fold: (i) to evaluate the antiamyloid activity of C60 and C70 fullerenes complexed with 1-methyl-2-pyrrolidinone; and (ii) to analyze the mechanism of amyloid disassembly, which is a principal point for the further successful use of fullerenes, and other types of nanoparticles in therapy of amyloid-related diseases.

To achieve these goals, a combination of several biophysical and biochemical techniques, including small-angle neutron scattering, have been used. Thioflavin T (ThT) fluorescence assays were used in a standard way for monitoring the protein fibrillation in solutions. An integrated AFM and SANS approach was intended to follow changes in the morphology of the fibrils interacting with fullerenes.

While the data of the AFM experiments were collected on the dried diluted samples the SANS analysis were performed on bulk concentrated solutions. This makes the SANS the unique technique to study complex multicomponent solutions.

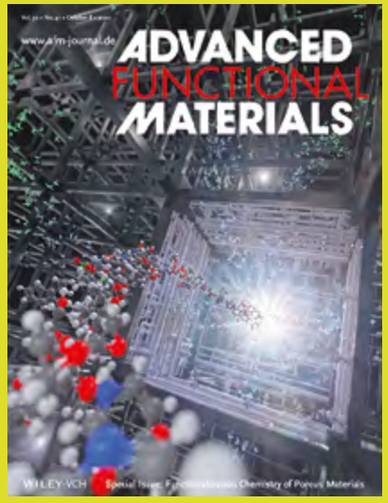


A schematic view of the fibrils destruction stages upon interaction with fullerenes.



ADVANCED MATERIALS

The authors describe how lipid-coated metal–organic framework (MOF) nanoparticles are taken up by cells via endocytosis. Once inside the cell, the MOF nanoparticles are degraded depending on the extracellular pH. The degradation product leads to pyroptosis—a programmed cell death involving the immune system, in which the cell membrane is perforated with pores leading to cell lysis. Ultimately, the nanoparticles may be used for immunotherapy.



ADVANCED FUNCTIONAL MATERIALS

A review of the functionalization chemistry of important porous materials in order to give the reader a fresh perspective that would stimulate them to build on the past and shape the future. Emerging challenges are also discussed in order to stimulate research commitment that will lead to future steps towards improving society at large.

CHEM SOC REV

Controlling the morphology of metal–organic frameworks and porous carbon materials: metal oxides as primary architecture-directing agents.

COVERS

SPECIAL ISSUE:

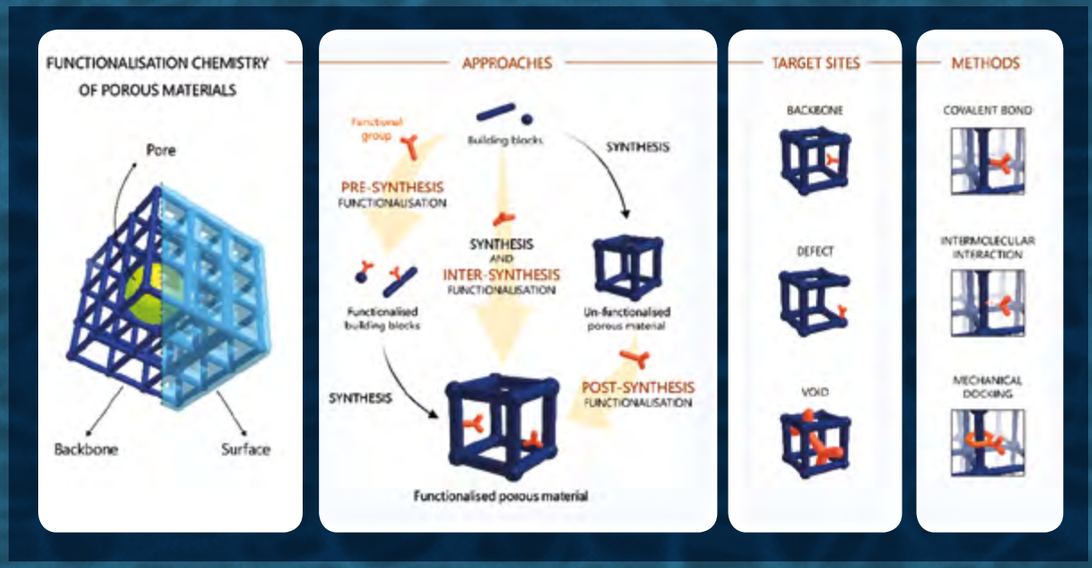
Functionalization chemistry of porous materials

Stefano Canossa, Stefan Wuttke

Advanced Functional Materials 2020, 2003875

Chemists are naturally more interested in what is there rather than what is not. We are spontaneously drawn to the chemical core of compounds and materials: the atoms, the ways in which they are connected and their interactions with electromagnetic radiation, other atoms/molecules or even biological systems. However, when it comes to porous materials we are less concerned about the atoms themselves rather the spaces between them (the "chemistry beyond matter").

The goal of this special issue is to critically review the functionalization chemistry of important porous materials in order to give the reader a fresh perspective that would stimulate them to build on the past and shape the future.



Main steps of the synthetic pathway for the functionalization chemistry of porous materials.

The full potential of pore chemistry design can be reached only by adopting the broadest perspective on the essence of porous materials. The structural interplay of matter and empty space are both essential aspects to the resultant properties of porous materials and should be accounted for when considering strategies toward pore chemical modification. From this perspective, the pores act as a functionalization platform where two kinds of modifiable parts can be identified: the material's constituents (matter) and the pore's void (empty space). Importantly, it should be noted that the synthesis and functionalization of porous materials are often convoluted, especially when functionalization is carried out at the same time of backbone construction.

To separate these two processes (backbone construction and functionalization) at a conceptual level, we define "functionalization" as the practice of decorating the materials backbone with chemical groups capable of exercising functional behaviours. This definition holds regardless of whether a functionalized material is obtained by strategically selecting the reactants for its synthesis or by modifying its structure after the assembly of the backbone structure is completed.

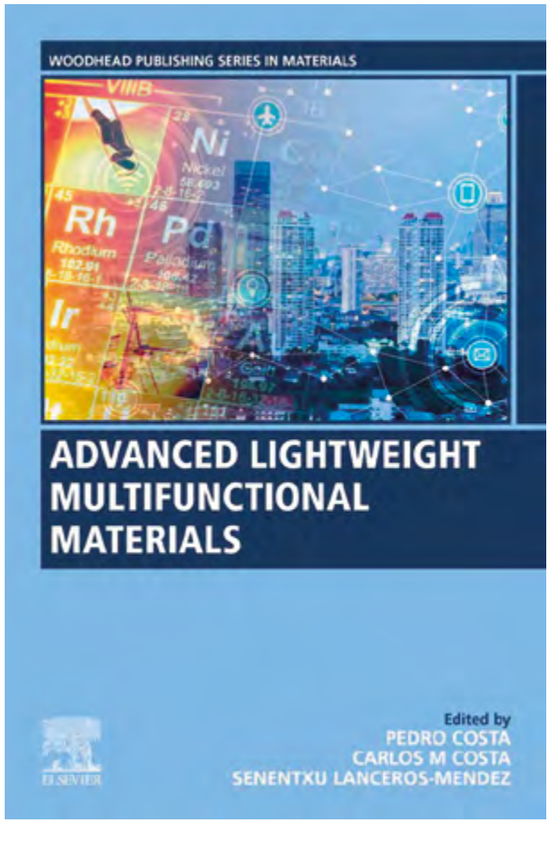
REVIEW PAPERS & BOOKS

Controlling the morphology of metal-organic frameworks and porous carbon materials: **Metal oxides as primary architecture directing agents**

Jongkook Hwang, Aleksander Ejsmont, Ralph Freund, Joanna Goscianska, Bernhard V. K. J. Schmidt and Stefan Wuttke
Chemical Society Reviews 49(11), pp. 3348-3422

Ionic Liquid–Polymer Composites: **A New Platform for Multifunctional Applications**

Daniela Maria Correia, Liliana Correia Fernandes, Pedro Manuel Martins, Clara García-Astrain, Carlos Miguel Costa, Javier Reguera, Senentxu Lanceros-Méndez
Advanced Functional Materials 30(24),1909736

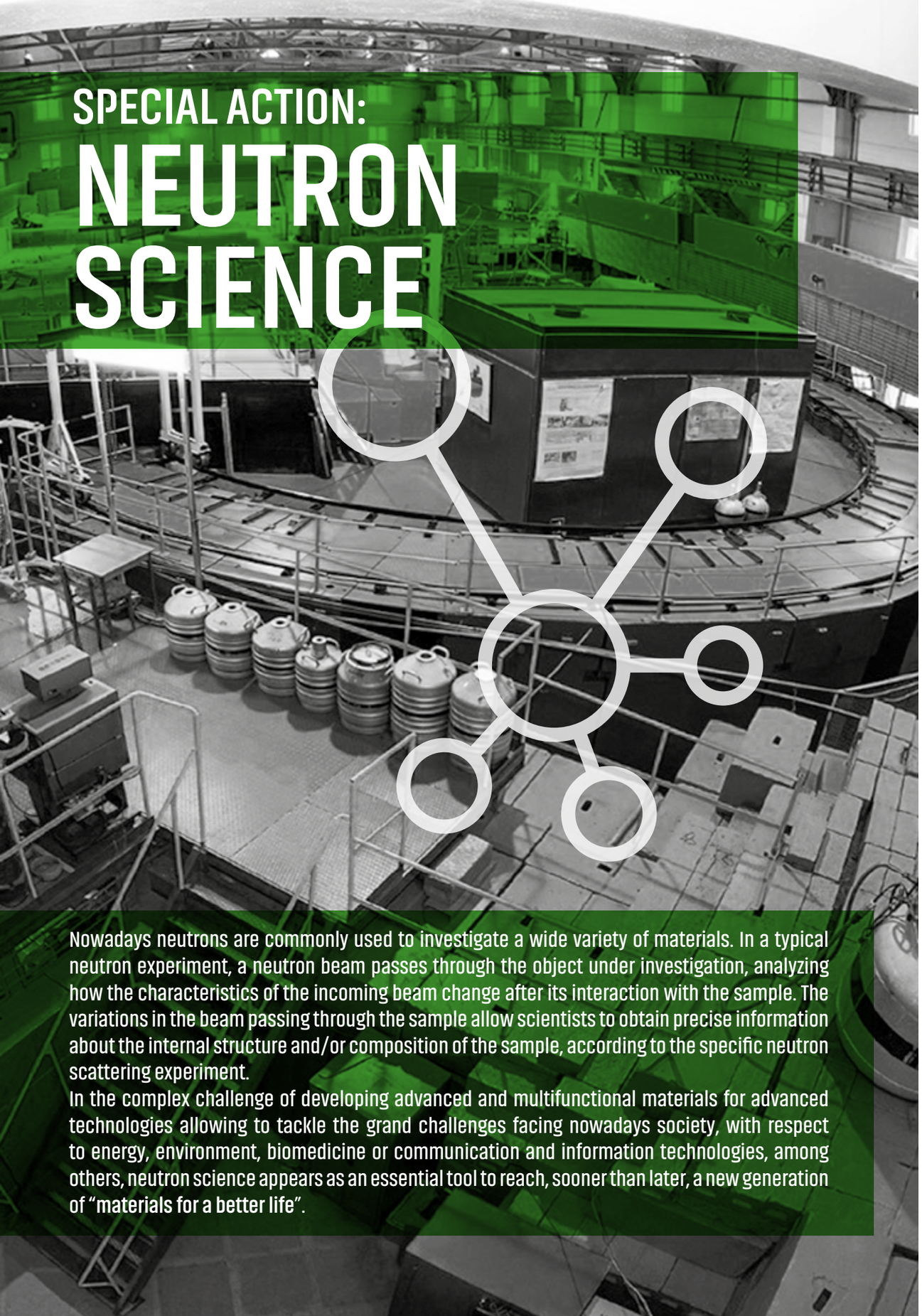


Advanced Lightweight Multifunctional Materials, 1st Edition

Pedro Costa, Carlos Costa
Senentxu Lanceros-Mendez
Woodhead Publishing

Porous multifunctional materials, thermochromic and thermoelectric materials, shape memory materials, piezoelectric multifunctional materials, electrochromic and electrorheological, soft materials, magnetic and photochromic materials, and more.

Advanced Lightweight Multifunctional Materials presents the current state-of-the-art on multifunctional materials research, focusing on different morphologies and their preparation and applications. The book emphasizes recent advances on these types of materials as well as their application. Chapters cover porous multifunctional materials, thermochromic and thermoelectric materials, shape memory materials, piezoelectric multifunctional materials, electrochromic and electrorheological, soft materials, magnetic and photochromic materials, and more. The book will be a valuable reference resource for academic researchers and industrial engineers working in the design and manufacture of multifunctional materials, composites and nanocomposites.



SPECIAL ACTION: NEUTRON SCIENCE

Nowadays neutrons are commonly used to investigate a wide variety of materials. In a typical neutron experiment, a neutron beam passes through the object under investigation, analyzing how the characteristics of the incoming beam change after its interaction with the sample. The variations in the beam passing through the sample allow scientists to obtain precise information about the internal structure and/or composition of the sample, according to the specific neutron scattering experiment.

In the complex challenge of developing advanced and multifunctional materials for advanced technologies allowing to tackle the grand challenges facing nowadays society, with respect to energy, environment, biomedicine or communication and information technologies, among others, neutron science appears as an essential tool to reach, sooner than later, a new generation of **"materials for a better life"**.

Our Ikerbasque Fellows in Neutronics are Members of the User Commitee of the IBR-2 reactor neutron source,Dubna, Russia

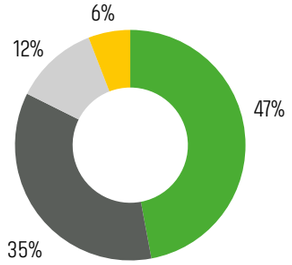
17

EXPERIMENTS PERFORMED

5

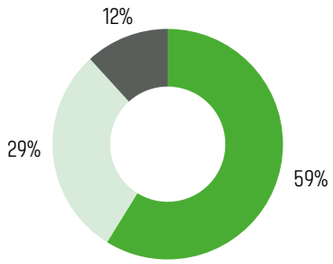
ACCEPTED PROPOSALS

- TECHNIQUE -



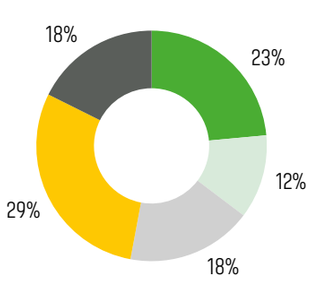
- SANS
- DIFFRACTION
- REFLECTOMETRY
- INELASTIC

- FACILITY -



- DUBNA
- ILL
- ISIS

- TOPIC -



- MAGNETISM
- MOFS
- ENERGY HARVESTING
- SOFT MATTER
- NANOPARTICLES

FLNP

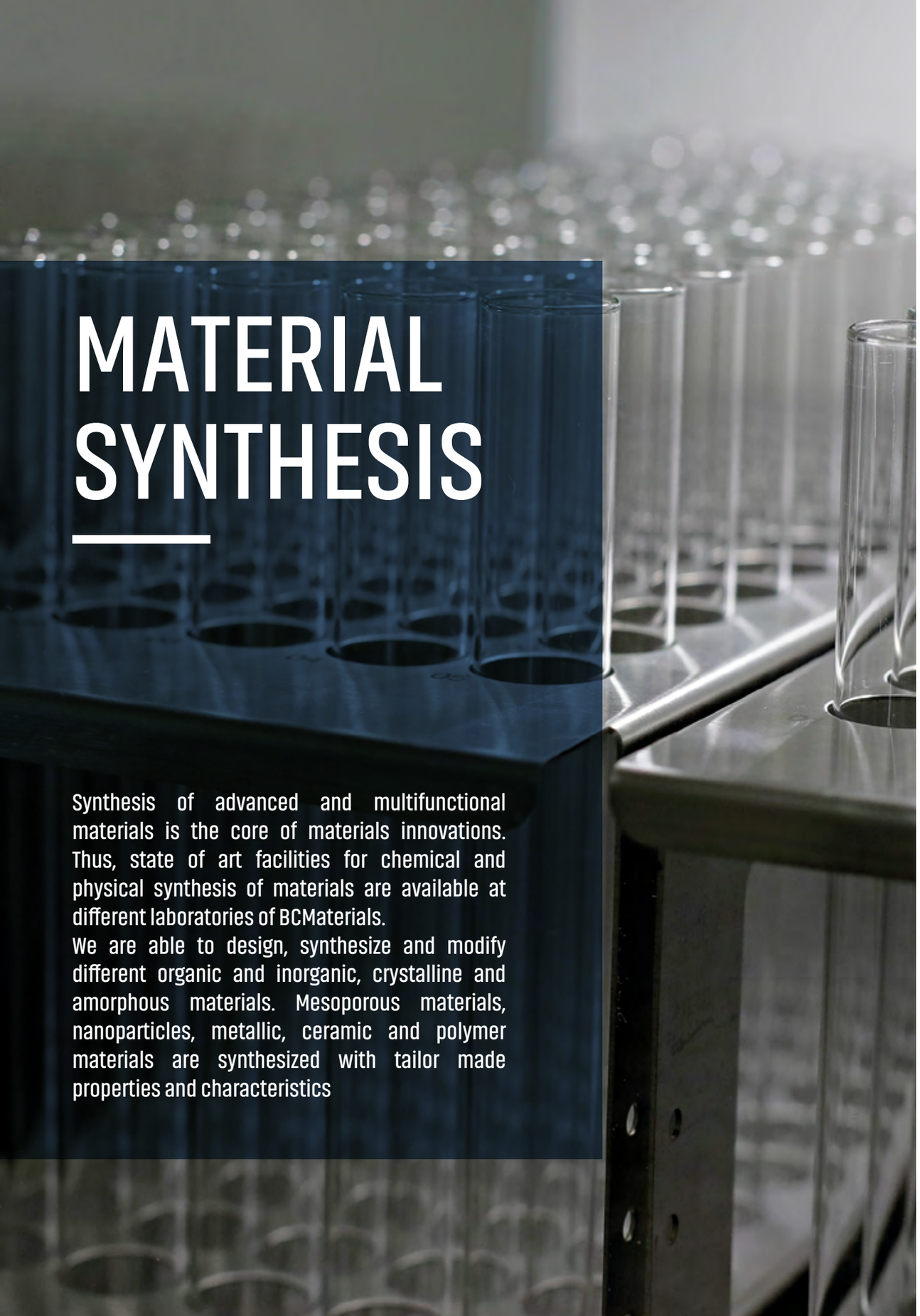
JOINT INSTITUTE FOR NUCLEAR RESEARCH

NEUTRONS FOR SCIENCE

Science & Technology Facilities Council
ISIS Neutron and Muon Source

FACILITIES & EXTERNAL SERVICES

As a research center of excellence, BCMaterials runs advanced infrastructures for materials synthesis, processing, characterization and integration into proof-of-concepts devices. Those facilities are open to all our collaborators and services are also provided whenever we can be useful to the scientific, technological or industrial sectors.



MATERIAL SYNTHESIS

Synthesis of advanced and multifunctional materials is the core of materials innovations. Thus, state of art facilities for chemical and physical synthesis of materials are available at different laboratories of BCMaterials.
We are able to design, synthesize and modify different organic and inorganic, crystalline and amorphous materials. Mesoporous materials, nanoparticles, metallic, ceramic and polymer materials are synthesized with tailor made properties and characteristics

Methods available

Among many other, our labs offer the possibility to use:

- Hydrothermal synthesis of wide scope of inorganic and hybrid materials and nanoparticles.
- Synthesis of mesoporous materials.
- Synthesis of monocrystalline and amorphous metals, and ceramics. It includes both Synthesis and thermal treatments.
- Synthesis of polymers and hydrogels.
- Floating Zone Optical Furnace.
- Crystal System Corp./ FZ-T-P1200-H-I-S 2013.
- Anton Parr Monowave 400 equipped with autosampler MAS24: High throughput synthesis of nanoparticles.
- Sigma 3-30KS: Centrifuge for isolation of nanoparticles.
- Büchi C-850 FlashPrep: Purification of small molecules.
- Büchi Rotavapor R-300: Distillation of solvents.

Among the services

We provide advice and support for the design and synthesis of materials with tailor made properties for specific applications including:

- Tailored physical properties: magnetic, electrical, mechanical or thermal, among others.
- Functional properties: photocatalytic, piezoelectric, magnetostrictive, magnetocaloric, among others.
- Advanced properties: self-healing, electrochromic, thermochromic, among others.

MATERIAL PROCESING

Materials are processed in a variety of shapes and forms either to explore their intrinsic properties, to tune them and/or to make them compatible with a variety of applications. From bulk materials to thin-films, from single phase to hybrid materials and composites, materials are processed in our laboratories.

Methods available

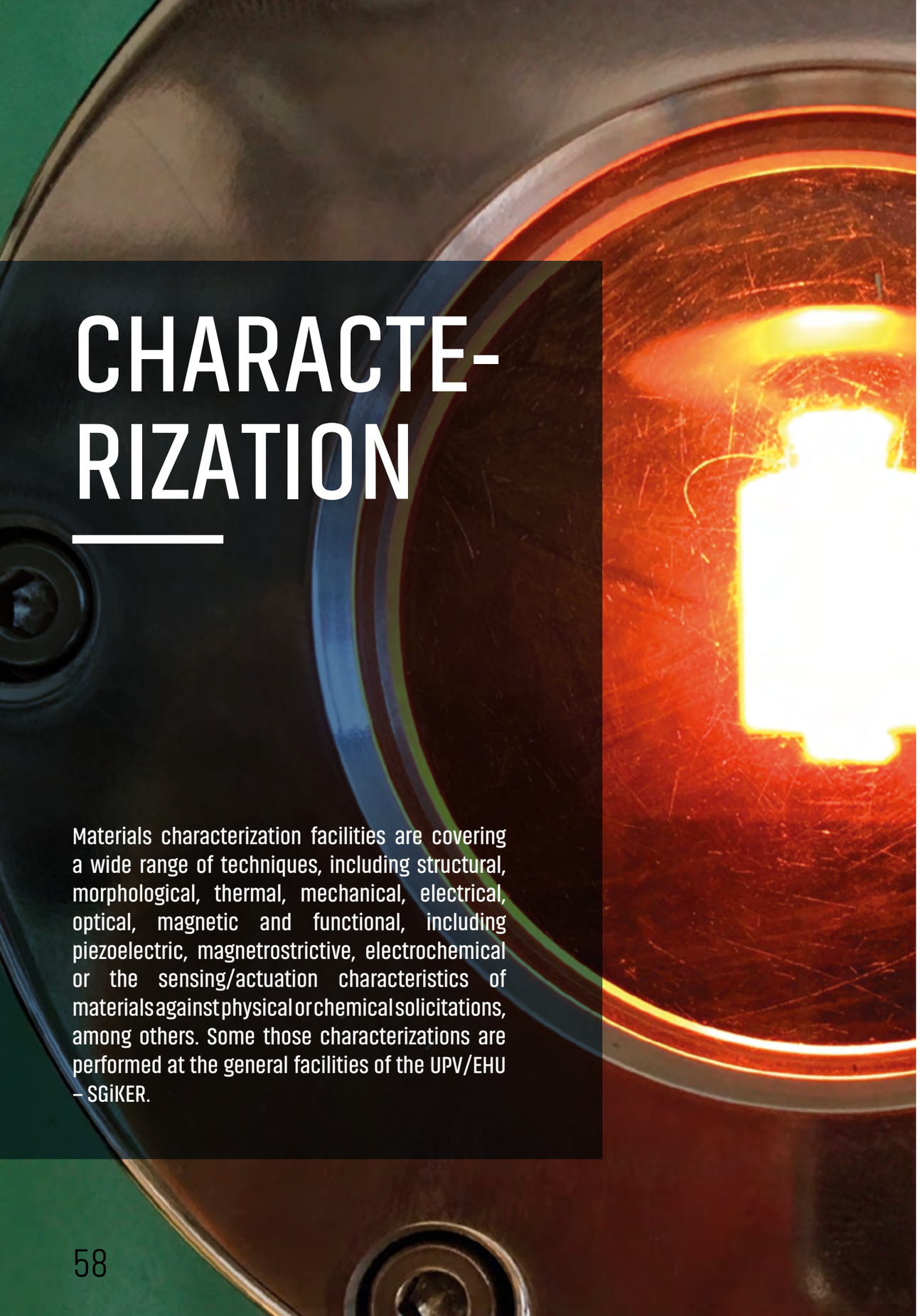
Among many other, our labs offer the possibility to use:

- Design and processing of composite polymer-filler materials.
- Design and processing of inks for screen, ink-jet and direct write printing.
- Processing of thin films by physical and chemical deposition techniques.
- Processing of materials in the form of filament, wires and films.
- Processing of materials in the form of nano- and micro particles.
- Mill Mini Rotary Tube Furnace.
- Melt Spinner.
- Turbomolecular pumped coater.
- A variety of printing and coating techniques.
- Thermal evaporator.

Among the services

We provide advice and support for the design and processing of materials with tailor made properties for specific applications including:

- Tailored physical properties: magnetic, electrical, mechanical or thermal, among others.
- Functional properties: photocatalytic, piezoelectric, magnetostrictive, magnetocaloric, among others.
- Advanced properties: self-healing, electrochromic, thermochormic, among others.



CHARACTE-RIZATION

Materials characterization facilities are covering a wide range of techniques, including structural, morphological, thermal, mechanical, electrical, optical, magnetic and functional, including piezoelectric, magnetrostrictive, electrochemical or the sensing/actuation characteristics of materials against physical or chemical solicitations, among others. Some those characterizations are performed at the general facilities of the UPV/EHU – SGiKER.

Methods available

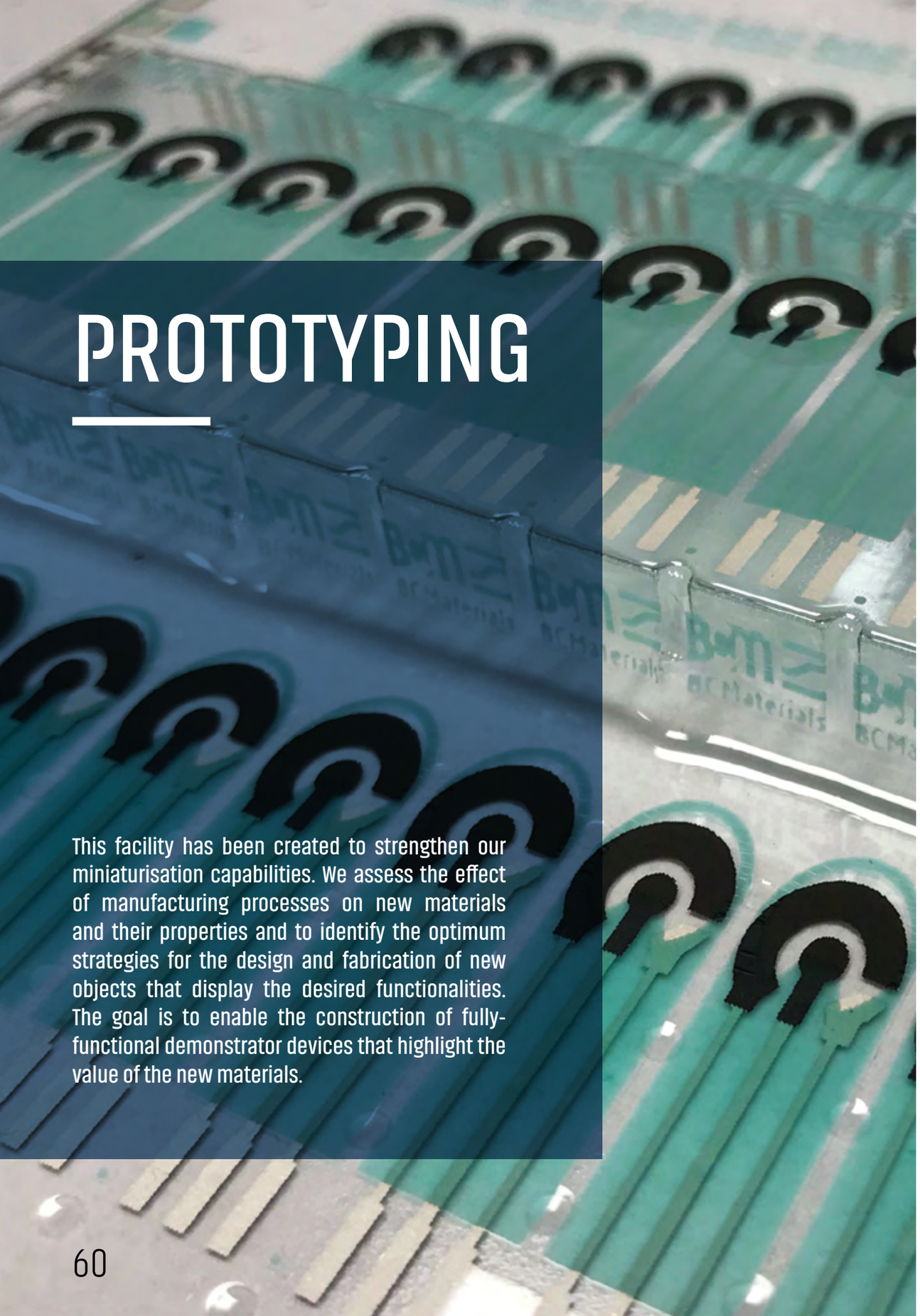
Among many other, our labs offer the possibility to use:

- VSM-Vibrating Sample Magnetometer. Microsense, LLC EZ7-20150305 MicroSense. To measure magnetic moment and coercivity of thin films or studying the magnetic properties of liquids, powders, or bulk samples.
- Perkin Elmer- Diamond DSC N536-0021 (P/N) Melting, Crystallization, Glass Transition, Polymorphism, Purity, Specific Heat, Kinetic Study and Curing Reaction.
- The Ossila Contact Angle Goniometer provides a fast, reliable, and easy method to measure contact angles and surface tensions of liquid droplets.
- Tensile strength tester Shimadzu Instruments AGS-J 500N. High precision and high reliability in material testing Forces are measured with a precision better than ±1% of indicated values, within the range from 1/1 to 1/250 of the rated force.
- Complex impedance equipment Agilent-Keysight E4980. Offering fast measurement speed and outstanding performance at both low and high impedance ranges.
- Custom made photothermal instrument equipped with high power red and near-IR lasers (LUMICS, 672, 784 and 808 nm of 4W of optical power), optical coupling lenses, thermometer based on phototherrmal IR camera (FLIR), thermal based power sensor, and control software.
- The VMP3 is a research-grade multi-channel potentiostat. With its modular chassis design, up to 16 independent potentiostat channels can be installed. The VMP3 can be equipped with additional capabilities, including low current measurement, impedance and high current via plug-in modules.
- Custom made Magnetoelastic measurement system: Automated experimental system for measuring magnetoelastic resonance from 10Hz up to 150 MHz and a field resolution of 8 A/m and maximum magnetic field of 11 kA/m.

Among the services

We provide advice and support for the characterization of a wire variety of materials properties, including the interpretation of the results and the possible ways to tune/modify those properties. Those characterizations include:

- Structural, morphological, thermal, mechanical, electrical, optical, magnetic, among others.
- Functional, including piezoelectric, magnetrostrictive, electrochemical, among others.



PROTOTYPING

This facility has been created to strengthen our miniaturisation capabilities. We assess the effect of manufacturing processes on new materials and their properties and to identify the optimum strategies for the design and fabrication of new objects that display the desired functionalities. The goal is to enable the construction of fully-functional demonstrator devices that highlight the value of the new materials.

We are equipped with additive, subtractive and forming techniques to process materials in various forms.

Among many others the methods available are:

3D printing (DLP and FDM), CNC milling (Roland MODELA MDX-50), CO2 laser cutting and engraving (Epilog Mini 18 CO2 laser engraver), blade cutting (Roland GS-24 CAMM-1) and thermoforming with suitable CAD/CAM software.

Any combination of processes is possible, including with printing methods such as screen-printing and inkjet-printing.

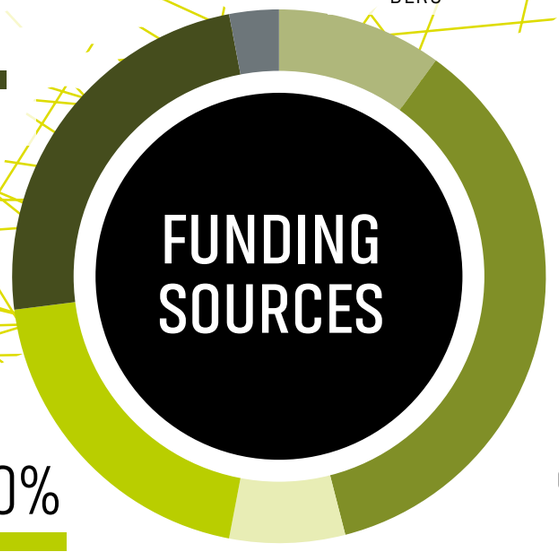
Among the services that we can offer we have:

- 3D printing of thermoplastic polymers and functional polymer thermoplastic composites by FDM/FFF.
- 3D printing of functional water- and solvent-based inks by direct ink writing.
- 3D printing of functional UV curable resins by selective laser sintering (SLS).
- 2D printing of functional inks by screen printing and inkjet printing.

FUNDING SOURCES & RESEARCH PROJECTS

Research projects represent the core of our activities as, most often in collaborative endeavours, set as specific framework for specific scientific or technological advances. Research project represent also timely innovations for the benefit of knowledge, technology and society.

FUNDING SOURCES



3% INVOICING

10% BERC

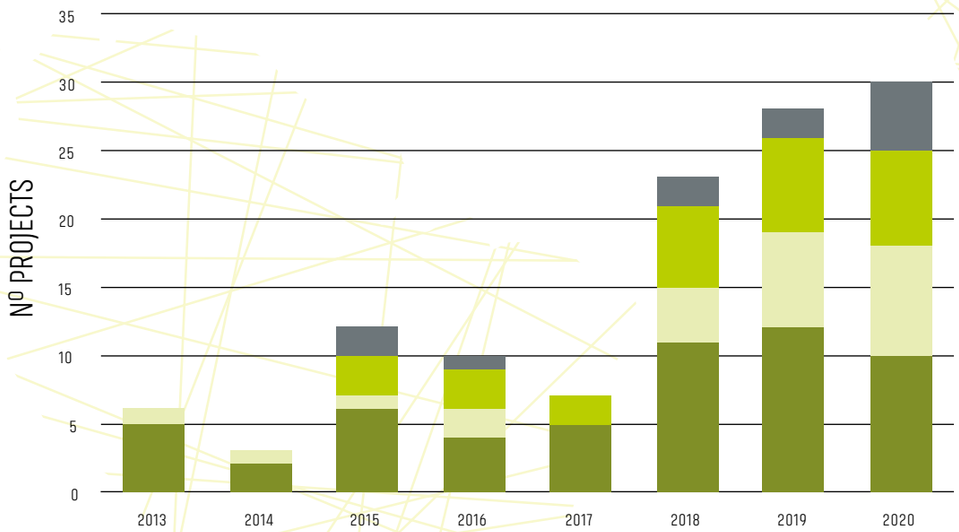
24% PRIVATE

36% BASQUE GOVERNMENT

20% INTERNATIONAL

7% NATIONAL FUNDING

30 RESEARCH PROJECTS



63 PROPOSAL SUBMMITED

27% ACCEPTED

51% REJECTED

22% PENDING

FINANCIAL BODIES

BASQUE RESEARCH PROJECTS

- M4INDUSTRY Microsistemas inteligentes avanzados e integrados en la industria. Monitorización, digitalización e inspección preventiva en entornos de producción.
  EJ/GV, ELKARTEK Tipo 1 KK 2019/00101 2019-2020
- IDEA Investigación y desarrollo en electrónica aditiva 3D
  EJ/GV, ELKARTEK Tipo 1 KK 2019/00039 2019-2020
- INTOOLII Herramientas de corte inteligentes sensorizadas mediante recubrimientos funcionales
  EJ/GV, ELKARTEK Tipo 1 KK-2020/00103 2020-2021
- FRONTIERS 2020 Superficies multifuncionales en la frontera del conocimiento
  EJ/GV, ELKARTEK Tipo 1 KK-2020/00108 2020-2021
- CARNK Inmunoterapia con CAR-NKs: nuevo tratamiento dirigido contra cáncer hematológico refractario
  EJ/GV, ELKARTEK Tipo 1 KK-2020/00068 2020-2021
- MMMFAVIND Materiales magnetoactivos multifuncionales para fabricación avanzada e industria inteligente
  EJ/GV, ELKARTEK Tipo 1 KK-2020/00099 2020-2021
- MULTIMAG Desarrollo de sensores y actuadores impresos multifuncionales basados en una nueva generación de tintas magneto activas
  EJ/GV PIBA PI_2018_1_0006 2018-2021
- PISCES Printable kesterites solar cells and interface optimization for high performance devices
  EJ/GV PIBA_2018_1_0087 2018-2021
- COVID SARS-CoV-2 prevención, detección y tratamiento.
  Ikerbasque 2020-2021
- ENSOL2 Desarrollo de tecnologías fotovoltaicas avanzadas
  EJ/GV, ELKARTEK Tipo 1 KK-2020/00077 2020-2021

NATIONAL PROJECTS

- MULTIMART Materiales martensiticos multifuncionales de nueva generación para aplicaciones en energía y actuación
  RETOS I+D RTI2018-094683-B-C53 2019-2021
- MAGTERIA Bacterias magnetotacticas como generadoras de nanoparticulas magneticas modelo y bio-robots para terapias especificas
  RETOS I+D MAT2017-83631-C3-2-R 2018-2021
- BASO Desarrollo de andamiajes biomiméticos activos para el estudio de microentorno de tumor en osteosarcoma
  PROYECTOS I+D+I PID2019-106099RB-C43 2020-2023
- PARASOL Perovskitas libres de plomo que emplean dicalcogenuro de metales de transición como capas de carga selectiva para la tecnología de células solares de perovskita
  RETOS I+D RTI2018-102292-B-I00 2019-2021
- ARISE All Inorganic Halide Perovskite Nanocrystals for Thin Film Solar Cells
  PROYECTOS I+D+I PID2019-111774RB-I00 2020-2023
- SUSANA Auto-reparación en superficie de desgaste por rozamiento
  PROYECTOS I+D+I PID2019-108103RB-C31 2020-2023
- JUAN DE LA CIERVA FORMACIÓN Manuel Salado
  FJCI-2017-31761 2018-2020
- JUAN DE LA CIERVA FORMACIÓN Ahmed Shalan
  FJC2018-037717-I 2019-2021

EUROPEAN AND INTERNATIONAL RESEARCH PROJECTS

- WEARPLEX Wearable multiplexed biomedical electrodes
  H2020-ICT-2018-2 2019-2021
- MOLEMAT Molecularly Engineered Materials and process for Perovskite solar cell technology
  ERC-COG 2017-2022
- MULTIFUN Enabling multi-functional performance through multi-material additive manufacturing
  H2020-NMBP-2018 2020-2023
- INDESMOF International Network on Ionic Liquid Deep Eutectic Solvent Based Metal Organic Frameworks Mixed Matrix Membranes.
  H2020-MSCA-RISE-2017 2018-2021
- SMILIES Two-dimensional Transition Metal Dichalcogenides as Charge Transporting Layers for High Efficient Perovskite Solar Cells
  H2020-MSCA-IF-2019 2020-2023
- UNESCO International Geoscience Programme
  (IGCP 682: Mine Tailing Revalorization) 2019-2021
- SOLARSENIC CHILE “Planta piloto del sistema de tratamiento de aguas para la remoción de arsénico mediante nanomateriales y energía solar, SolArsenic, validado en condiciones reales”
  Fondo Fomento Chile IT 1910006 2020-2021

PRIVATE PROJECTS

- FLAT-LIT Desarrollo de tinta electroluminiscente imprimible, termoconformable e inyectable
  WALTER PACK 2019-2021
- SERCON Dispositivo de medida y seguridad para sistemas de construcción avanzados
  ULMA 2020-2021
- WIND2GRID Investigación aplicada a subestaciones flotantes para eólica offshore
  VIUDA DE SAINZ 2020-2021
- Electrodo para una batería de litio-ion y aplicaciones avanzadas en sensores
  DYNASOL 2019-2021
- NUEVOS GRADOS DE ABS SUS COPOLÍMEROS Y BLENDS TERMOPLASTICOS CON FUNCIONALIDADES AVANZADAS PARA AUTOMOCION. E-MOBILITY
  ELIX POLYMERS 2020-2023

RESEARCH NETWORK

<162
COLLABORATORS

<100
INTERNATIONAL

JAPAN
RUSSIA
CHINA
EGYPT
CHILE
ARGENTINE
COLOMBIA
PORTUGAL
FINLAND
UKRAINE
PENNSYLVANIA
IRAN
THAILAND
NEW MEXICO
CALIFORNIA
SOUTH ARABIA
INDIA
ALGERIA
AUSTRALIA
SOUTH DAKOTA
GREECE
CANADA
FRANCE
ITALY
UK
TUNISIA
SOUTHAFRICA
GERMANY
POLAND

18
NATIONAL

40
REGIONAL

28 RVCT
12 PRIVATE

TECHNO-LOGICAL INNOVA-TION

BCMaterials is also committed to technology innovation and transfer. Specific innovations in materials, processes and their applications are sometimes patented and transferred before being published to add economic value to our activity.

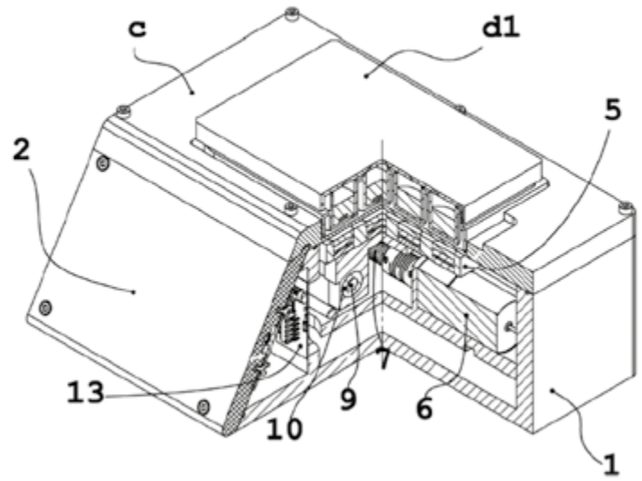
Modular magnetically driven bioreactor system for cellular cultures and biomedical applications

2

PATENTS
BATTERIES
AND TISSUE
ENGINEERING

Senen Lanceros Mendez, Nélson José Fernandes Castro,
Vitor Manuel Gomes Correia, Clarisse Marta de Oliveira Ribeiro

The present invention refers to a magnetically driven bioreactor system for advanced tissue regeneration strategies. The stimuli generated by the bioreactor can be converted in mechanical or electromechanical signals by appropriate scaffold materials for muscle, neural or bone tissue regeneration. Similarly, these bioreactors may be used in other biomedical fields, such as controlled drug delivery and magneto-transfection, based on the previously mentioned principles



TRAINING ACTIVITIES

As a center of excellence, BCMaterials is committed, mostly together with the UPV/EHU but also with other regional, national and international institutions, to the training of the next generation of great scientist. This is our duty, but mostly our conviction and pleasure. We put our expertise, laboratories and human resources to motivate, guide and advise the next generation of scientist in all our areas of expertise. Thus, BCMaterials offers a complete PhD program to graduate students from all around the world who wish to start a research career in a materials science-related field at a top international research institution. We also collaborate in various official master and graduate programs, as well as open its facilities for internships.

As an Excellence Research Center BCMaterials works at the forefront of the main scientific and technological challenges of current society. Our commitment with society also focusses on training of the new generation of great scientists, together with our colleagues and partners from the UPV/EHU.

Universidade do Minho
Manual de Identidade Visual

Universidad del País Vasco
Euskal Herriko Unibertsitatea

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Université Mohamed V de Rabat

11

PhD Defended

AUTHOR		TITLE
CRISTIAN MENDES FELIPE	/ 01 /	"Multifunctional Photocurable Advanced Materials for Electronics and Sensing Applications"
NÉLSON JOSÉ FERNANDES CASTRO	/ 02 /	"Design, Construction and Validation of a New Generations of Bioreactors for Tissue Engineering Applications"
ANDER REIZABAL LOPEZ-PARA	/ 03 /	"Tailoring Bombyx mori Silk as Multifunctional Material for Advanced Applications"
JIVAGO SERRADO GOMES AGUIAR NUNES	/ 04 /	"Polymer based sensors fabricated by printing technologies"
SYLVIE RIBEIRO	/ 05 /	"Tailoring electroactive polymer nanocomposites for novel muscle tissue engineering applications"
PAULA GONZÁLEZ SAIZ	/ 06 /	"Environmental sensors based on geometrically modified magnetoelastic resonators functionalized with MOFs"
URIBARRI GOIKURIA	/ 07 /	"Jatorri naturaleko polimeroetan oinarritutako nanokonpositeen garapena / Natural origin polymer-based nanocomposite development"
AIZETI BURGOA BEITIA	/ 08 /	"Design and development of high-performance thermoplastic vulcanizates with vibration damping properties"
YASSINE RAOUI	/ 09 /	"Computational Design of Organic-Inorganic perovskite solar cells through drift-diffusion simulation and processes fabrication"
PATRICK HIRSCHLE	/ 10 /	"Controlling Functionalization and Morphology of MOF Particles – employing Novel Characterization Techniques"
IRATI RODRIGO	/ 11 /	"High field, high frequency and temperature adjustable AC magnetometer for magnetic hyperthermia characterization"

6

UNDERGRADUATED

10

MASTER THESES

BCMaterials offers Master Scholarships to perform research in areas as diverse and challenging as materials for sensors and actuators, which are critical for the internet of Things and Industry 4.0; materials for advanced biological and biomedical applications; materials for energy (both generation and storage) or materials for environmental monitoring and remediation.

Master in New Materials

Its objective is to provide a solid training in the most current methodologies for the synthesis, characterization, properties and applications of new materials, in fields as diverse as biomaterials, nanomaterials, intelligent materials, materials for energy, electronics, catalysis, etc.

UNIVERSIDAD DE CANTABRIA

eman ta zabal zazu
Universidad del País Vasco
Euskal Herriko Unibertsitatea

Master in Environmental Contamination and Toxicology

The master will train the students as a professionals in the biological assessment of the health of ecosystem, both marine and fresh water, and terrestrial.

eman ta zabal zazu
Universidad del País Vasco
Euskal Herriko Unibertsitatea

Master in Biomedical Research

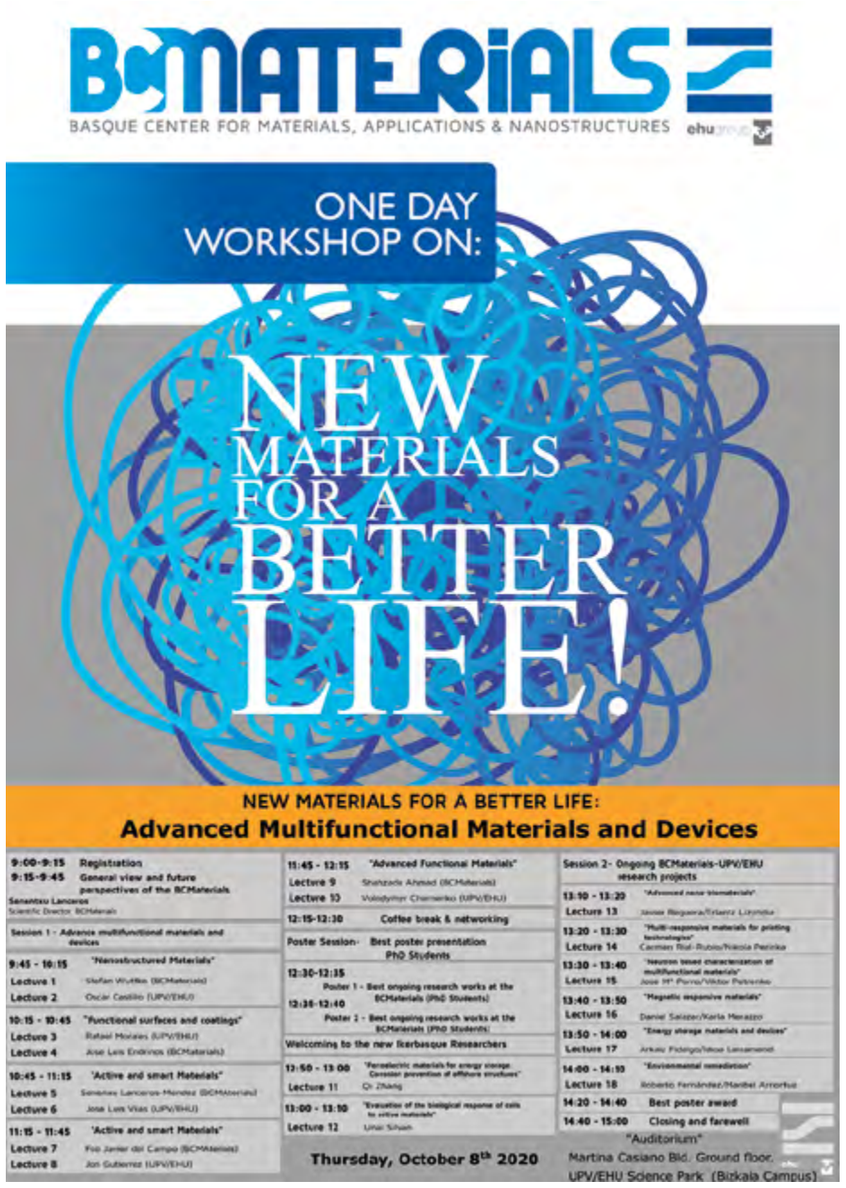
The master offers updated training on the molecular, cellular and physiological mechanisms involved in the development of the disease, necessary to carry out research that leads to the achievement of valid results and conclusions on topics of biosanitary interest.

eman ta zabal zazu
Universidad del País Vasco
Euskal Herriko Unibertsitatea

OUTREACH ACTIVITIES, WORKSHOPS & CONFERENCES

Working for the benefit of society. Society and fellow scientist must know our motivation, our aims, our way of facing science and technology and our results. Thus, communication activities, from the general to specialized public, represent one of the most rewarding of our activities.

AT
BCMATERIALS



150
ATENDEES

60
BCM

51
EHU

39
OTHERS

BCMaterials organized this 2020
the 8th edition of the New Materials for a Better Life
Workshop, entitled:

Advanced multifunctional materials and devices.

This edition was held in a dual on-site and on-line modes. With 19 invited talks, this year the NM4BL workshop showed the potentials of the five main research lines and activities within the center to the research community of the Basque Country (including CIC, BERQ and Technological centers), but also to other 15 institutions from 11 different countries all along the world including Spain. With a participation of 153 attendees, this edition has confirmed the consolidation of the international character of our small but high impact yearly event, closely linked to the internationalization of the BCMaterials research activities.

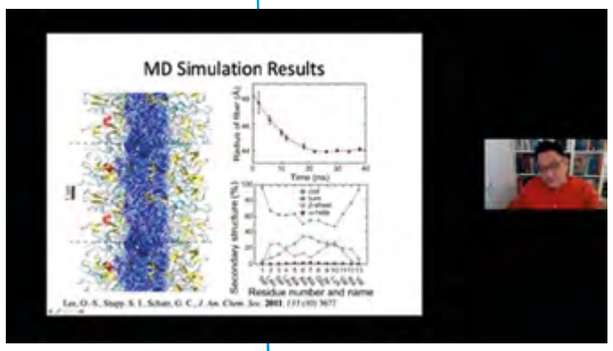
OTHERS

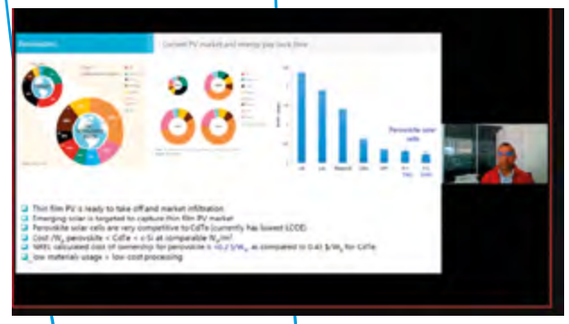
- Abalonyx AS / 1
- Achucarro / 1
- CICEnergigune / 1
- CNRS-Orleans / 3
- CSIC / 1
- Gaiker / 1
- ICMAB / 12
- IMASMED / 1
- Istituto Nazionale di Ricerca Metrologica / 3
- University of Southhampton / 1
- RI.SE / 1
- University of Buenos Aires / 1
- UDL / 1
- University of Minho / 1
- Qatar Environment and Energy Research Institute / 1
- UNICAN / 1
- UNIOVI / 1
- Universidad de Deusto / 1
- Universidad de Extremadura / 1
- Universidad de San Carlos de Guatemala / 1
- Universidade Federal do Rio Grande do Norte / 2
- Universität Augsburg / 1
- University of Monastir / 1

AT
BCMATERIALS

35
SEMINARS AND INVITED TALKS

Science and society cannot be separated. Science outreach activities are amazing in so many ways. They can generate excitement and interest in science with students and the general public. Providing science outreach activities is also a great way to gain a deeper understanding of science and its applications, and develop valuable communication skills.



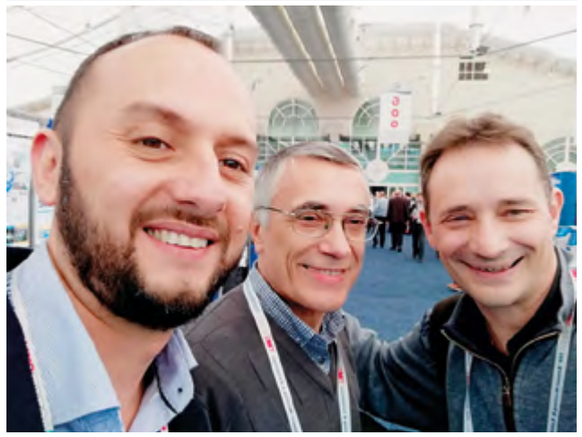


OUT
BCMATERIALS

24
INVITED TALKS

12
ORAL PRESENTATIONS

17
POSTER CONTRIBUTIONS



14
EVENTS

SCIENCE FOR SOCIETY

BCMATERIALS AT THE HERCULES EUROPEAN SCHOOL

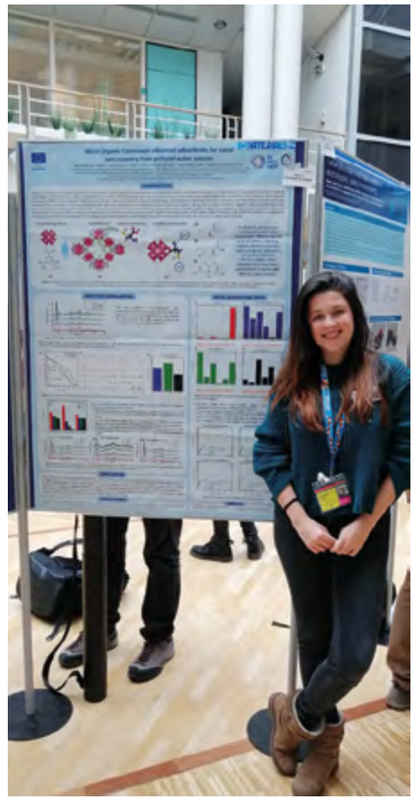
BCMATERIALS TXIOTESIA UNIBERTSITATEA.NET

SCHOOLS VISITS

Our commitment is with society. At BCMaterials we train our future scientist on how to communicate their scientific and technical advances in an open an accessible way to all levels of our society.

"Equipped with his five senses, man explores the universe around him and calls the adventure Science."

Edwin Powell Hubble



Women Science Day 2020

COLLABORATION AGREEMENT BETWEEN BCMATERIALS AND ELHUYAR

SOMOS CIENTÍFICOS Y CIENTÍFICAS SÁCANOS DE AQUÍ

Ander Reizabal participante en la zona Titanio: "*la divulgación no es solo una forma de enseñar nuevos conocimientos sino de mostrar la importancia de ser críticos con nuestro alrededor*".

The support of other organizations is essential if we want to spread our knowledge and to share our advances in an effective way. With their support we organize open initiatives to attract a new generation of scientist.

"Science & everyday life cannot & should not be separated"
Rosalind Franklin

ANNUAL EVENT: DISCOVERING THE NOBEL LAUREATES

INTERVIEWS
IN DIFFERENT MEDIA


BCMaterials, Basque Center for Materials, Applications and Nanostructures, es un centro de investigación incluido en la red vasca de excelencia BERC (Basque Excellence Research Centers). La misión del BCMaterials es el desarrollo de investigación interdisciplinar de elevado calidad e impacto en materiales activos y multifuncionales con propiedades avanzadas. Nuestra actividad se extiende desde el desarrollo de conocimiento básico a la exploración de nuevas aplicaciones. De este modo, nuestra misión es generar conocimiento en nuevas generaciones de materiales, así como trasladar este conocimiento en soluciones y dispositivos (multi)funcionales para el beneficio de la sociedad.

Rasgos que le diferencian ...

- Liderazgo en el área de materiales avanzados y tecnologías relacionadas con nuevos materiales
- Compromiso con los principios de Excelencia y Liderazgo.
- Transparencia, eficacidad y eficiencia en gestión de recursos.
- Satisfacción y desarrollo de investigadores y staff.
- Asegurar el máximo retorno a la sociedad.
- Contribución a la sostenibilidad.

Qué quieren aportar a la sociedad ...

BCMaterials está comprometido con ser un centro de investigación de referencia internacional en el área de materiales activos, multifuncionales y nanoestructurales. Nuestro compromiso con la sociedad no se extiende solamente a la investigación, desarrollo y transferencia tecnológica, sino también a la divulgación y la formación de la nueva generación de científicos y otros profesionales. De este modo, construimos alianzas fuertes con instituciones, organizaciones y empresas locales, nacionales e internacionales para ofrecer nuestra experiencia y nuestros recursos con el objetivo de impulsar la innovación en materiales y tecnologías relacionadas.

Parke.eus


Tecnología Vasca

Vicomtech lidera el proyecto Border UAS

BCMaterials extiende un puente hacia la transición energética

El centro planea desarrollar materiales avanzados para cambiar el paradigma de conversión y almacenamiento de energía

«La transición energética requiere de materiales innovadores»

«La conversión de energía solar a eléctrica en perovskita ha reemplazado a la tecnología de silicio»

Emplea una nueva estrategia para materiales de cátodos

EMPRESA XXI. El Periodico de la Industria Vasca


La celulosa, para fabricar materiales avanzados y dirigir a la sociedad hacia una economía circular

Una revisión de la literatura científica realizada en la UPV/EHU resalta el potencial de los materiales híbridos basados en nanocristales de celulosa

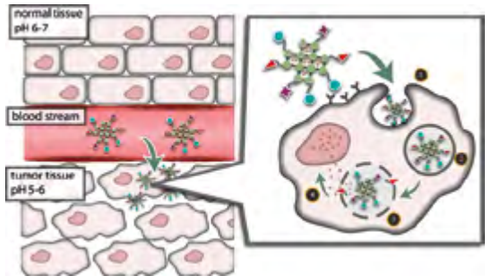
17/06/2020

El profesor Erlantz Lizundia Fernández. Foto: UPV/EHU

En la última década han aumentado las publicaciones científicas y patentes sobre el polímero natural más abundante, la celulosa. Mediante la revisión de dichos trabajos, un investigador del Departamento de Expresión Gráfica y Proyectos de Ingeniería de la UPV/EHU ha estudiado el nivel de desarrollo de los materiales nanohíbridos formados por nanocristales de celulosa combinados con partículas orgánicas e inorgánicas. Está centrado en los

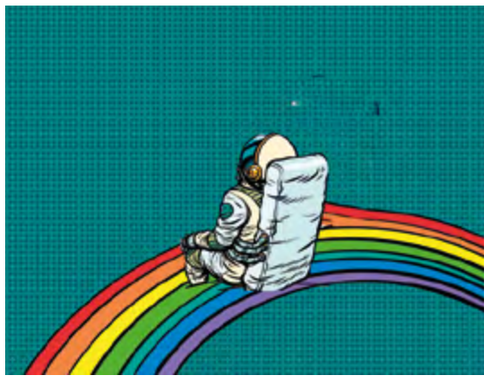
Interempresas.net

MAPPING IGNORANCE



Mappingignorance.org
Zientziakaiera.eus

ANNUAL EVENT SCIENCE FROM THE COUCH

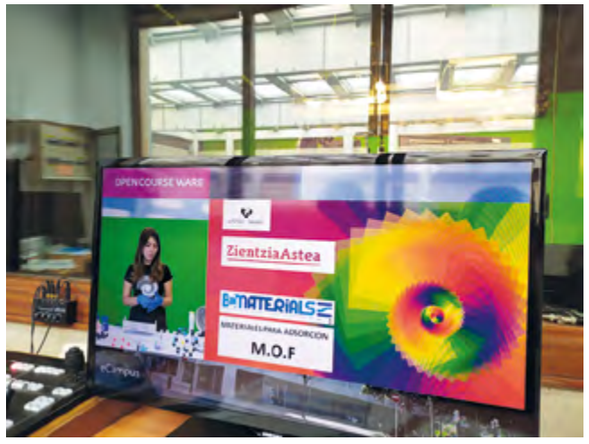


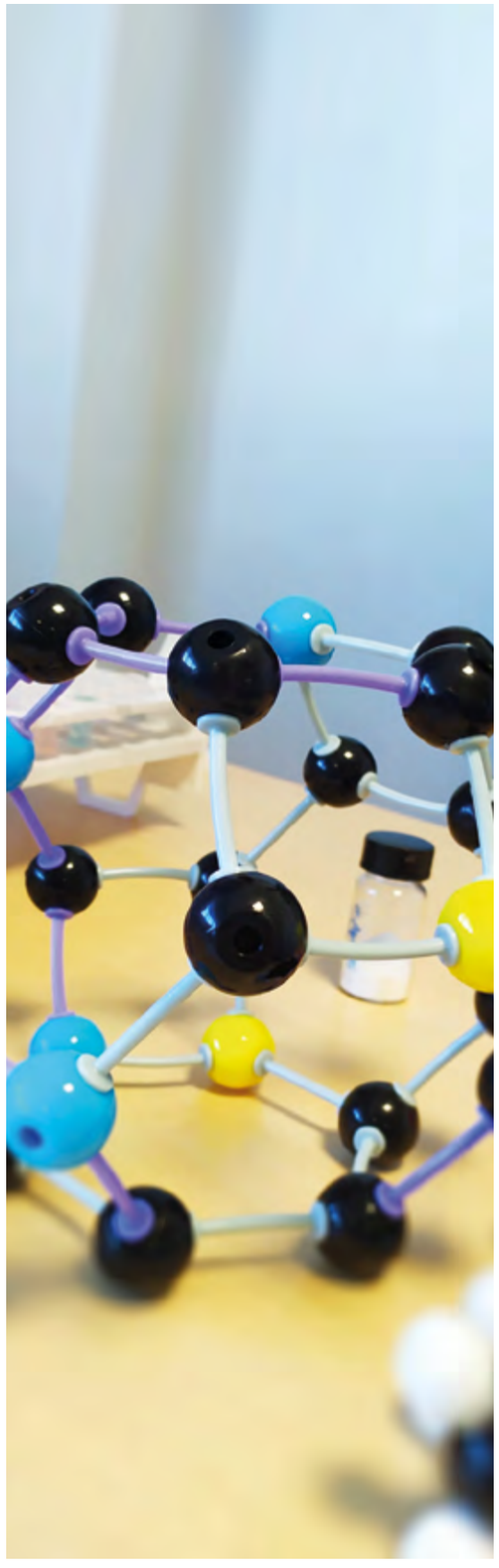
Youtube Channel

We are here to contribute for a better future!

Newspapers, blogs, videos in Social Media are useful tools to reach the different type of public from experts to society in general. Share our knowledge and have information about the challenges and needs from our society is a two-way communication path that needs to be strong and fluid. At BCMaterials we do our very best to stay always accessible.

ZientziaAstea





Zientzia Astea is the Science, Technology and Innovation Week organized by the University of the Basque Country so that all those people who are curious about their surroundings, be they young or old, boys, girls or adolescents, have the opportunity to see, hear, feel and talk about science with those who work on it every day.
We love participating every year in this initiative showing how amazing science can be! Magnetic materials that can levitate, materials that can adsorb toxic substances just changing their colours, solar cells...

So much fun!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2020 ANNUAL REPORT

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