



NAME: INSTITUTE OF RESEARCH ON ELECTRON MICROSCOPY AND MATERIALS (IMEYMAT)

INSTITUTION : UNIVERSITY OF CÁDIZ.

COUNTRY : SPAIN.

Profile :

- IMEYMAT is an initiative of the **University of Cádiz (UCA)** to support and boost research, transference of technology and spin-off activities, in addition to specialized instruction and training, in the fields of materials and their applications. A Center of Excellence with international recognition and more than 15 years of tradition as a UCA Research Unit.
- Our researchers make **studies of materials** by advanced methodologies performed on cutting-edge equipment having all together a value over 25M€. IMEYMAT is a virtual space which serves to its tens of members as a platform to identify new opportunities of cooperation and financing, by promoting development of collaborative R&D+i projects..
- For our investigations, **Scanning (SEM) and Transmission (TEM) Electron Microscopy** are often of a great importance. UCA is recognized as a reference in Electron Microscopy by the value of its instrumental facilities; the capabilities, expertise, high-impact productivity of its researchers; and its network of contacts with world-wide leading groups working in such family of techniques. This singularity is considered as the more distinctive feature of IMEYMAT.
- The goals of IMEYMAT are both **specialized and interdisciplinary**: EM procedures are used and developed plus routines for interpreting the EM results, and at the same time other complementary techniques are applied; various types of materials with multiple applications are analyzed, and training on their knowledge is received and given; experts on Solid State Physics and Chemistry, and on Materials Science and Engineering operate in a synergic way.
- We advance by **joining and sharing efforts, resources and ideas**, open to collaborate with other researchers and technologists from public centers and industry professionals, meeting both an international vocation and a local and regional development commitment. It is our aim to generate master or doctorate schools as far as pre- or post-doctoral training networks in the frontiers of the knowledge of the science and technology of materials.

Activities :

- Research and development
- Education and divulgation
- Service and transferences of the scientific results to the industry

Expertise on following materials:

- Catalysts
- Semiconductors (amorphous and single-crystalline)
- Photovoltaic and Photocatalytic
- Synthetic Diamond
- Electronic, optical and magnetic
- Nanoparticles
- Metals
- Ceramics
- Composites
- Polymers
- Nanoparticles
- Chemicals
- Nanofluidic
- Chemicals
- Electrochemical
- Sensoric
- Additive fabrication (3D and 4D Printing)

Actual research domains concerning materials technology / Competences :

- **Research Team of Solid State Chemistry and Catalysis:**
 - **Environmental Catalysis:** Synthesis, characterization and testing of materials with catalytic applications in processes of cleaning of pollutant atmospheric emissions and liquid effluents. Concretely: materials based on rare-earth oxides and metals supported onto these oxides, applied to depuration of automotive gas pollution (TWC: Three Way Catalyst), and elimination of organic pollutants from industrial sewage watering (CWAO: Catalytic Wet Air Oxidation), and of volatile organic compounds (VOC's).
 - **Catalysis and Energy:** Synthesis, characterization and testing of materials with catalytic applications in processes related to green production of energy. Concretely: materials based on rare-earth oxides and metals supported onto these oxides, applied to hydrogen generation to be used as a fuel with a low environmental impact (CO oxidation, steam, dry, and aqueous phase reforming, water gas shift, preferential oxidation of CO in the presence of H₂).
- **Research Team of Physical Properties of Amorphous Solids:**
 - Study of the structure, and of the optical, electrical and thermal properties of amorphous semiconductors.
 - Thin film deposition of amorphous semiconductors.
 - Photo-induced phenomena in light-sensitive materials.
 - Support to technologies for solar-thermal energy production.
 - Software development for the control of instrumentation and data acquisition.
 - Software development for the analysis of data associated to optical behaviors.

- **Research Team of Simulation, Characterization and Evolution of Materials (SCEM):**

- **Nanofluidic systems:** Development and characterization for uses as fluids in heat transference applications for concentration solar energy. Theoretical calculations and analyses based on molecular dynamics.
- **Synthetic diamond:** Focused on industrial applications as power electronics. Studies of surface finishing for general applications.
- **Photovoltaic and Photocatalytic nanomaterials:** Development of these nanomaterials and physical-chemical characterization based on spectroscopies. Modelling based on the functional density theory.

The main purpose of the SCEM group is to generate knowledge in the field of Physical Chemistry of Materials. In addition, our team manage two Homologated Technical Services with a strong scientific component, which are: (i) Simulation, Characterization and Evolution of Materials: studies by instrumental and computational techniques of chemical-physical properties of materials: metals, semiconductors, ceramics, paints, etc. (ii) Laboratory of Systems and Materials for Solar Energy: Macroscopic and microscopic evaluation of photovoltaic efficiencies. Characterization of solar cells, determination of I-V curves, recombination kinetics, efficiency surface mapping at different wavelengths till micrometric resolutions, texture studies of photoactive surfaces. Characterization of cells based on nanostructured electronic materials. Determination of band gap and electronic structure of nanostructured semiconductors.

- **Research Team of Instrumentation and Environmental Science:**

- **Development of new methods for the synthesis of nanoparticles:** Materials of biological origin, mainly extracted from plants and seaweeds, are used as reducing agents of a metal precursor species, by the application of high-power ultrasounds.
- **Use of Sonogel-Carbon materials as the base for the fabrication of (bio)sensor devices:** Sonogel-Carbon is a special type of graphite-like materials developed by our group and built by sol-gel technology, which are excellent platforms for the immobilization of (nano)materials and the fabrication of sensors for specific purposes.
- **Development of novel electrode (nano)materials:** Several kinds of modified materials, even structured at the nanoscale, based on Sonogel-Carbon, nanoparticles, carbon nanotubes and conductive polymers can be obtained.
- **Study of the (nano)materials employed for the fabrication of electrochemical (bio)sensors, along with the characterization of the obtained devices:** By electrochemical (CV, DPV, EIS, SECM) and structural (SEM, TEM, EDS, XRD, FTIR, AFM, UV-vis, etc.) characterization techniques.
- **Application of our developed (nano)materials for the fabrication of (bio)sensors:** Immobilization of enzymes on different (nano)materials for agrifood, biomedical or environmental applications. In addition, (bio)sensors of the type of “inhibition of response” are also developed and applied.

- **Research Team of Nanomaterials Structure and Chemistry:**

- Chemical and structural characterization of nanostructured materials by advanced techniques from Electron Microscopy, in particular of materials for Heterogeneous Catalysis.
- Development of methodologies for the characterization of nanomaterials by Electron

Microscopy.

- Characterization till atomic scale of functional nanoparticles.

- **Research Team of Applied Magnetism and Optics:**

- **Magnetic properties of materials:** magnetization (dependence with respect to temperatures and applied fields), magnetic susceptibility (as a function of temperature).
- **Optical properties of materials:** optical absorption, fluorescence, refraction indexes, dielectric functions and thickness (by spectroscopic ellipsometry).
- **Magnetic and magneto-optic sensors.** Absorption and reflectivity measurements, Faraday rotation, etc.
- **Electrical properties of nanostructured materials.**
- **Synthesis of semiconductors (quantum-dots) and magnetic nanoparticles with applications in biomedical and environmental fields.**
- **Scanning Probe Microscopies** (AFM, MFM, SThM, C-AFM, STM, etc.) for the study of materials with nanometric dimensions.

- **Research Team of Novel Materials Processing via Sol Gel:**

- **Biomaterials:** The fabrication of novel biomaterials for implants or for making a specific biological activity is a continuously growing area of research that includes experts from many disciplines. We aim to contribute (to improve or generate), with solids based on silica aerogels, to the varied list of materials proposed to substitute or regenerate human bones.
- **Environmental materials:** Routes for the fixing of the heavy metals into residual waters. Synthesis of hydrophobic silica/chitosan gels for these amino radicals fixes the heavy-metal cation for the depuration of polluted water flows. The detailed study of the porous structure is carried out inside the respective aerogel into which the structure of humid gel is preserved.

- **Research Team of Materials Science and Engineering:**

- **Engineering of GaAsSbN semiconductor alloys for high-performance solar cells and photodetectors.**
- **Characterization and evaluation by electron-microscopy techniques of semiconductor nanowires for micro- and opto-electronic applications.**
- **Multiple systems of thin films and nanostructures based on the activity of binary (InN, AlN, GaN), ternary (InAlN, InGaN, AlGaN) and quaternary (InAlGaN) III-N nitrides for optoelectronics, power electronics and photovoltaic technology.**
- **Synthetic diamond for materials engineering.**
- **Reinforced polymers for aeronautic applications.**

The **general goal** of the group “Materials Science and Engineering” is **to contribute to the development of the science and engineering of the fabrication and application of functional and structural materials** by means of (i) their micro- and nano-structural and compositional characterization by techniques mainly based on accelerated electron beams (SEM and TEM), X-rays or spectroscopies; (ii) the modelling of structures at different scales in addition to the development of new TEM methodologies and the simulation of TEM images by intensive computational methods; and (iii) theoretical-empirical studies of the mechanical, optical or electronic behaviors. This is done to get knowledge on the relationships among the structure of materials at different length scales, their varying properties, their methods of syntheses or processing; thus in order to elaborate and propose design rules for these materials

to get the envisaged applications.

- **Research Team of Materials and Nanotechnology Innovation**

- **Materials and additive fabrication:** applications for the production consumer goods in areas of aerospace, naval, food and other industrial sectors.
- **Nanoanalysis and Nanoprocessing of materials:** by electron nanoscopies and focused ion beams.
- **Development of nanocomposites of polymeric matrix:** with graphene and other 2D materials, metallic nanoparticles, wastes and functional additives. Main applications and fields of photonics, photovoltaics and industrial engineering.

Our main aim is to create richness from the application of the knowledge in the fields of Materials Science and Engineering, and Nanotechnology. The R&D+I activity of our group is focused in two work lines: (i) Investigating the relationship among nanostructure, processing and function of materials in order to improve the production of new materials and the creation of innovative products with market potential. (ii) Development of materials for additive fabrication (3D printing). We pay a special attention to the contribution of the nanotechnology for improving these materials to innovate in the field of 3D and 4D printing.

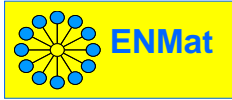
Available research infrastructure:

- The researchers from IMEYMAT are **users of groups of scientific equipment of UCA** linked to (i) the own Institute or its integrated Research Groups, (ii) the Central Facilities of Scientific and Technical Investigations (SC-ICYT), and (iii) the Service of Supercomputation; **with an estimated investments over 26 M€** :

- Equipment of IMEYMAT and its Integrated Research Team : 12.000.000 €
- Division of Electron Microscopy of the UCA Central Facilities SC-ICYT : 8.000.000 €
- Laboratory of Solid Sample Preparation for Microscopies of the SC-ICYT : 1.000.000 €
- Division of Additive Fabrication (3D Printing) of the SC-ICYT Facilities : 1.000.000 €
- Divisions of X-ray Diffraction and Atomic Spectrometry of the SC-ICYT: 2.000.000 €
- CAI Hardware of Supercomputation: Cluster for Supporting Research : 1.000.000 €

- **FACILITIES OF ELECTRON MICROSCOPY** : Approximately **10 M€** directly owned by IMEYMAT and its Research Groups, or by the Divisions of “ELECTRON MICROSCOPY” and “LAB OF SAMPLE PREPARATION” of the SC-ICYT Facilities:

- 5 TEM Microscopes (Jeol 1200EX, 2011, 2100, 2010F, FEI Titan3 Themis 60-300)
- 4 SEM Microscopes (FEI Quanta, NanoSEM 450, Quanta 3D FIB, Jeol JSM-6701F CL)
- 5 TEM Single-Tilt Holders from Gatan (3 ST, 1 ST Heating, 1 ST Vacuum Transfer)
- 6 TEM Double-Tilt Holders from Gatan/Jeol (4 DT, 1 DT Be analytic, 1 DT 1-N₂ cryogenic)
- 3 TEM Tomography Holders Gatan/Fischione (1 High-Tilt 1-N₂, 1 Ultra-Narrow Gap, 1 Titan)
- 3 Laboratories of Specimen Prep (LPM materials, Mod4 catalysis, CML4.80 semiconductors)
- 4 Systems of Ion Milling by Ar⁺ Bombardment (Gatan PIPS / PIPS-LV, Fischione 1010 / 1050)
- 2 Systems for Plasma Cleaning of TEM Holders (Fischione 1020, Gatan Solarus 950)
- 2 Stations of HV for TEM Holders (Fischione 9020 in F-1020, GP [Campus] Glove Box)
- 2 Laboratories for Digitalization and Analysis of Micrographs (Rooms DITABIS SC, Module2)



European Network of Materials Research Centres

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