TOPIC 6
Nanoenergy: production, storage and environment

Research lines:

6.1. Catalyic nanostructures for energy carriers. Fuel cells.
6.2. Nanomaterials for solar cells and photocatalytic processes.
6.3. Nanoestructured systems for energy storage.
6.4. Nanosensors for pollution and gas detection

Goal:

-application of nanomaterials to energy production and storage

Challenges:

-improve efficiency and duration
-overcome conventional methods less environmentally friendly

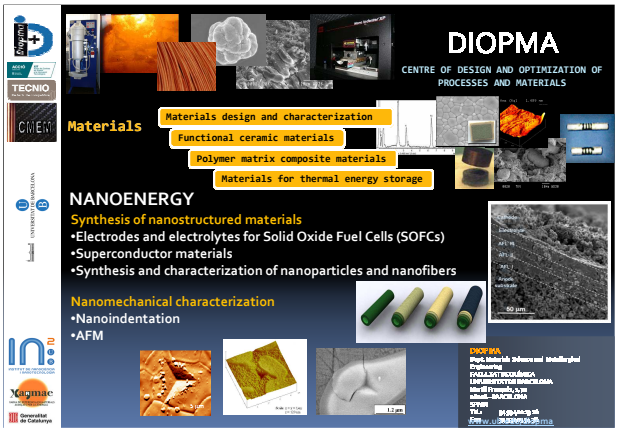
The research Groups:

Design and Improvement of Processes and Materials (DIOPMA)
(Dep. Materials Science and Metallurgical Engineering, Fac. Chemistry)
Mercè Segarra Rubí (Titular); Elena Xuriguera Martín (Lector); Joan Formosa Mitjans (Lector); Mònica Martínez López (Lector); Jaume Calvo (PhD Student)

Solar and Photovoltaic Energy Group
(Dep. Applied Physics and Optics, Fac. Physics)
Jordi Andreu Batallé (Titular); Joan Bertomeu Balagueró (Titular); José Miguel Asensi López (Agregat)
Fredy Enrique Rojas Tarazona (Col·laborador); Jorge Alberto García Valenzuela (Postdoc)
Álvaro Caballero Lorenzo (PhD Student)

M2E-Nanoenergy and Electronic Materials
(Dep. Electronics. Fac. Physics)
Alejandro Pérez Rodríguez (Catedràtic); *(Joan Ramon Morante Lleonart (Catedràtic))*; Frank Güell Vilà (Titular)

Catalysis and Advanced Materials (MATCAT)
(Dep. Inorganic Chemistry, Fac. Chemistry)
Narcís Homs Martí (Catedràtic); Pilar Ramírez de la Piscina (Catedràtic); Xianyun Liu (PhD Student); Lukasz Bednarczuk (PhD Student); Sònia Rodriguez Abril (PhD Student); Alberto Córdoba Sola (PhD Student)



DIOPMA
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Current main fields:
-Relationship between nanomechanical and magnetical properties of Copper Ferrite
-Epitaxial growth of nanolayers of metal oxides ($SrTiO_3$, etc.) on oriented metallic tapes (Cu, Ni, etc.)
-Growth of Graphene on special substrates

We offer to members:
-Nanomechanical characterization
-Rehological characterization
-Manufacturing of metal alloys (up to melting point of 1700℃)
-Expertise in oriented Cu, Ni, Ag, etc for different applications
-Synthesis and characterization of nanoparticles and nanofibers

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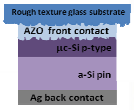
The **Solar Energy Group** has focused its research on the improvement of **silicon-thin-film-based solar cells**.

In particular, to optimize light absorption by the devices:
-development of transparent conductive oxides for front/back contacts
-introduction of nanometric layers as optical couplers between the front transparent conducting oxide and the amorphous silicon device
-development of textures on the glass substrate to enhance light scattering
-introduction of rare-earth based up-converters for widening the spectral response of the devices

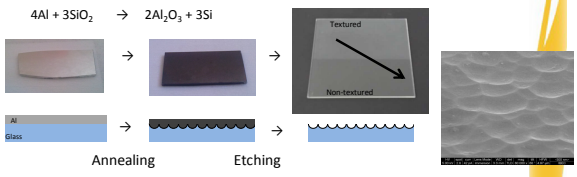
Aluminium Induced Texturing (AIT) of glass substrate

Objective: Texture the glass substrate prior to front TCO deposition to enhance absorption in active layer.

Redox reaction between the glass (SiO_2) and a thin Al layer at high temperature annealing:



$4Al + 3SiO_2 \rightarrow 2Al_2O_3 + 3Si$



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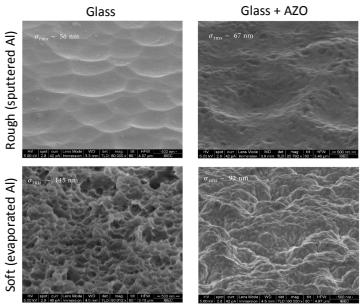
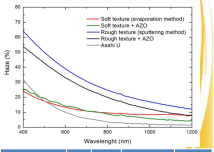
AIT of glass substrate





Sample	σ_{rms} (nm)	R_s (Ω/sq)	Integrated T (400-800 nm) (%)	Haze @ 600 nm (%)
Soft texture	56	-	92.4	13.2
Rough texture	146	-	91.3	38.9
Non-textured glass+AZO	9	5.3	81.8	-
Soft texture+AZO	67	7.0	81.6	14.1
Rough texture+AZO	92	9.5	73.5	33.1
Asahi-U	25	9.3	78.3	10.1

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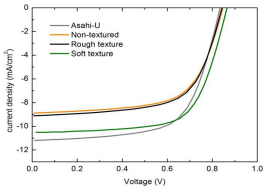
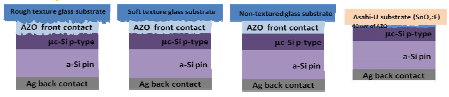
AIT of glass substrate



Application of textured substrates to p-i-n a-Si solar cells

	Asahi-U	Soft texture	Rough texture	Non-textured
J_{sc} (mA/cm²)	11.11	10.50	9.10	8.87
V_{oc} (V)	0.84	0.84	0.85	0.86
FF (%)	0.65	0.68	0.64	0.59
Eff (%)	6.1	6	4.9	4.5



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Available:

-Plasma-CVD i HW-CVD for amorphous and hydrogenated nanocrystalline Si, intrinsic or doped

-Sputtering of transparent conducting oxides and passiving layers of Si (ZnO, Al2O3,..)

Useful to have:

-printing techniques of semiconducting or metallic materials (Ink-jet printing, laser-transfer of solid or liquid layers)

M2E-Materials electrònics i nanoenergia

Solar Energy Materials and Systems Group / IREC

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Prof. J.R.Morante
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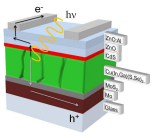
Research lines:

-Development of new materials and concepts for high efficiency PV devices. Low cost processes for sustainable high efficiency chalcogenide based technologies.

- Advanced Raman scattering methodologies for identification of defect clusters and nanometric secondary phases in chalcogenide PV processes.



The research activity includes the development of new and emerging chalcogenide semiconductors and device architectures for cost efficient technologies compatible with sustainable mass deployment requisites and with very low environmental impact.

A special emphasis is given in the development of kesterite ($Cu_2ZnSn(S,Se)_4$ based technologies, where relevant device efficiencies (among the highest ones reported at world level) have been achieved.

Activities /techniques of interest for other groups:

Technology platform suitable for fabrication of thin film solar cell prototypes (up to 10x10 cm², substrate configuration) including:

Synthesis
- ✓ Electrochemical workshop
- ✓ Spray pyrolysis reactor with controlled atmospheres
- ✓ Screen and ink-jet printing workshops
- ✓ Chemical Lab
- ✓ Furnaces for thermal treatments under controlled atmospheres

Device
- ✓3 Sputtering deposition systems for back contact & windows
- ✓CBD for synthesis of buffer layers
- ✓ Thermal evaporator

Optoelectronic Device/cell characterization
- ✓Scriber for delineation of cells
- ✓Solar simulator (AAA, 6" x 6")
- ✓ Spectral response & EQE / IQE measurements (Bentham PVE300)

Activities /techniques of interest from other groups:

- ***Deposition techniques of nanometric sulphide layers: Zn(O,S), Zn(Mg,O), Zn(Mg,O,S) with controlled composition and thickness in 10 nm – 50 nm range (development of new buffer layers in chalcogenide thin film solar cells)***
- ***Deposition techniques of nitride layers (nitrides of Mo, Ti, Wf, Si, Ni…) with controlled composition and thickness (50 – 1200 nm<) for development of new substrates***
- ***Laser processing for monolithic integration of PV modules (controlled scribing of TCO / absorber / back contact layers)***
- ***Advanced electrical and opto-electronic modelling/simulation of thin film solar cells***

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Energy storage and energy harvesting group:

Electrochemical energy storage

i. Lithium and post lithium batteries
ii. Flow redox batteries. Fully organics batteries.
iii. Semi-solids batteries
iv. Supercapacitors
v. Metal-air
vi. Photo electrocatalysis

Fully autonomous systems:

i. Nano sensors
ii. Thin films batteries
iii. Harvesting systems.

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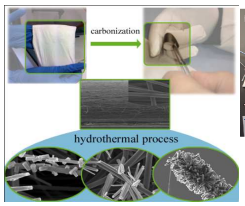
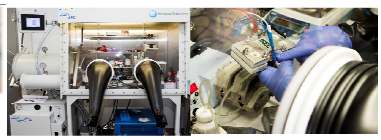
Material synthesis (scale up)





Test systems and facilities.
Simulators in a smart grid.

MATCAT-Design of nanostructured materials and study of their catalytic properties

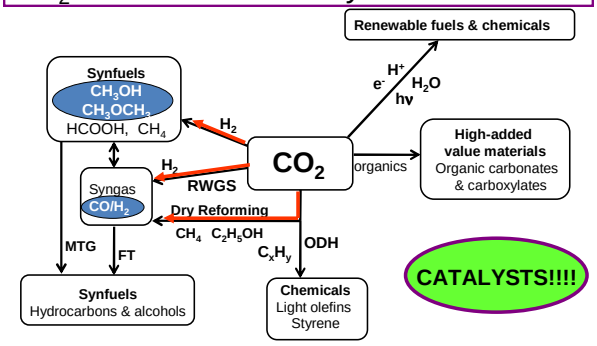
Research objectives:

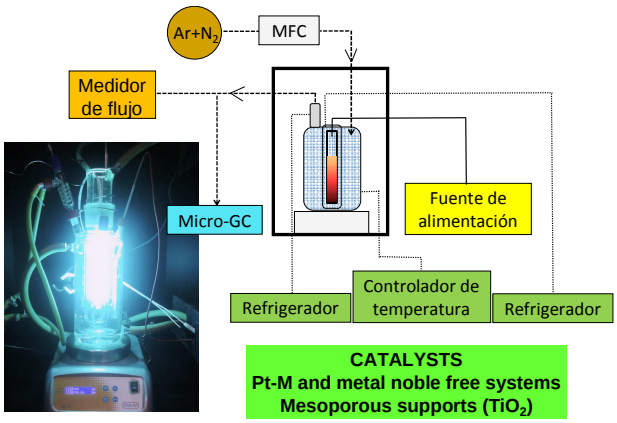
Chemical Energy Storage and Energy Carriers

-**Catalytic CO_2 conversion (reduction and valorization):**
processes to methane, methanol, DME and higher oxygenates, syntehtic fuels (F-T), CO_2-assisted reformation….

-**H_2 production (new sustainable routes):**
from biomass-derived resources and using catalytic reformation and photocatalytic methods

CO_2 valorization ⟺ recycle & C1 source





MATERIALS I CATALISI

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Preparation of tailored new catalysts based on supported and unsupported active phase (metals, …) for high selectivity to different processes.

Characterization of materials to establish relationship between the catalytic behavior and their characteristics.

Available:

-Catalyst synthesis: sol-gel, inert gas/vacuum, microwave techniques..
-In-situ DRIFT-MS equipment, TG-DSC-MS and TPR, TPD, TPO-MS…
-Reaction systems and photocatalytic equipment

Requested:

-Collaboration within the design of nanostructured catalysts….
-Collaboration within the characterization of catalysts using HRTEM, AFM, STM…