CHALLENGES

Real time nano CHAracterization reLatEd techNoloGiEeS

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PROJECT DETAILS

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PROJECT TITLE:	Real-time nano-CHAracterization reLatEd techNloGiEeS
ACRONYM:	CHALLENGES
STARTING DATE:	01 April 2020
DURATION:	36 months
TOPIC:	DT-NMBP-08-2019 Real-time nano-characterisation technologies (RIA)
EU CONTRIBUTION:	4,691,566.25 euro

4,691,566.25	14	7	36
EU CONTRIBUTION	PARTNERS	COUNTRIES	MONTHS DURATION

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 861857".

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PARTNERS

7 SMEs

5 RTOs and Universities

2 Large Enterprises

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THE AIM

Context

- The lack of adequate process metrology is hindering and delaying further products development in the field of silicon-based industry. To **ensure fast process and product quality control is a major concern of nanomaterials producers**.
- Conventional optical methods (μRaman, μPhotoluminescence, FTIR spectroscopies) have **resolution and sensitivity limits** for wider use in semiconductor industry.
- TEM-based techniques **are destructive** and **not compatible with in-line control**.

The project **CHALLENGES** aims to develop and demonstrate a new nanoscale metrology technology based on plasmonic enhanced optical spectroscopy enabling Non-Destructive real-time inline measurements at the factory floor.

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OBJECTIVES

- **Obtain Plasmonic AFM-based tool usable at fab-floor**

The system will be compatible with cleanroom environment, and it will reduce at minimum the need of human feedback in the loop, providing automated tip-focus alignment system.

- **Automate the tip positioning**

The XY piezo scanning stage will be capable of moving heavy (>125 g) and large (> 300 mm in diameter) samples with microscale resolution for tip placement in the test locations.

- **Optimize the plasmonic tip: unconventional materials and new shape**

Use of non-noble metals coupled with optimized light wavelengths to maximize plasmonic resonance, resolution and measurement capability in Silicon devices factory environment.

- **Train a Neural network in a machine-learning framework**

A lower resolution instrument will be able to inspect the entire wafer and to “guess” and fast pre-determine specific areas to zoom in for detailed analysis through high resolution AFM instrumentation.

- **Demonstrate the new technique in 3 relevant industrial application contexts:** Semiconductor, Si-Photovoltaics, and 2D Materials industries.

Revolutionary spectroscopic system for real time nanotechnology characterization compatible with semiconductor production

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CONCEPT

INNOVATIONS

- New non-noble materials for plasmonic tips
- Highly efficient nanoscale optical antennas
- Spectrometer centrally incorporated into the AFM
- Cleanroom-compatible and automatic tip-objective alignment
- Machine learning algorithms between tip enhanced tools

MAIN OUTCOMES

- Multipurpose nano-optical techniques using plasmonic enhanced Raman, IR and PL signals for characterization analyses directly within the production lines with real-time capabilities
- Improved resolution and sensitivity with the use of plasmonic effects
- Metrological protocols for real-time characterization from the lab to the factory floor

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AMBITION

AFM integrated with Raman/PL/IR **spectroscope**

Optical Spectroscopy	Far field resolution	CHALLENGES resolution	Plasmonic enhanced technique	Measurable physical value	Affected product characteristics
Raman	0.25 μm	20 nm	TERS	Strain, crystallinity, doping level	Junction leakage (dark current on CIS), transistor performance, yield of thin PV cells
		5 nm	2- Photon TERS		
Photo-luminescence (PL)	0.25 μm	50 nm	s-SNOM	Dislocations, lifetime, doping level	Transistor performance, metal contamination during production, junction leakage
		20 nm	TEPL		
Infrared (IR)	5-10 μm	20-50 nm	s-SNOM	Oxide composition, dangling bonds	Transistors threshold voltage shift, oxides reliability to breakdown, less 1/f noise

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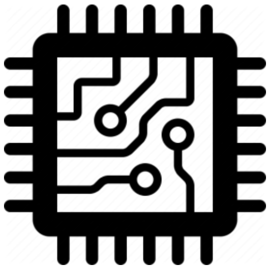
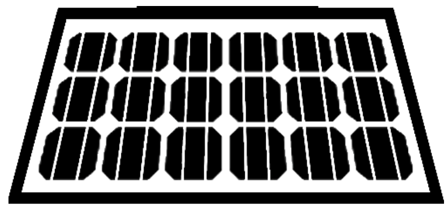
REAL APPLICATION CONTEXTS

Semiconductor industry



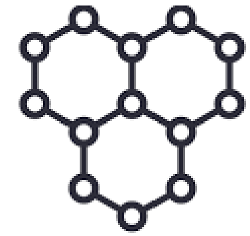
110 nm CMOS Image Sensors and nanoscale transistors for logic and RF; Strain engineering in Si-Ge advanced CMOS technology nodes

Silicon Photovoltaics



Thin c-Silicon solar cells and modules

2D Materials



Wafer-scale synthesis and production of devices based on Graphene and 2D Materials

CHALLENGES WILL ENABLE:

- real-time non-destructive detection down to the nanoscale of the strain
- gate-oxide composition for quality/reliability control
- metal contamination control
- advanced characterizations able to be performed in a reliable and non-destructive way, in real-time and with a resolution at the nanoscale

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METHODOLOGY

WP1

SAMPLES MANUFACTURING

- Development and manufacturing of materials for characterization tests and round robins

WP2 –WP3

DEVELOPMENT

- Development of clean room compliant tips
- Development of the instrumentation

WP4 – WP5

VALIDATION AND DEMONSTRATION

- Application and validation of novel in-line characterization techniques
- Development of commonly agreed protocols

WP6 – WP7

SUSTAINABILITY AND NETWORKING

- Assessment of the environmental impacts
- Exploitation opportunities
- Dissemination, communication, training and networking

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MAIN IMPACTS

- **Improvement of speed of nanoscale characterization procedures from several hours to less than 1 minutes** leading to a significant increase in industrial competitiveness

- **Reduction of the time and resources** needed for nanomaterial development, upscaling, and commercialization of new technology nodes

- Enhancement of the **ability to control the quality and reliability of products**, with consequent improvement of product lifetime

- **Environmental benefits** in terms of reduction of **industrial waste and reduction of energy and natural resources consumption** proved by LCA

- Increase the **competitiveness of EU Semiconductors, Photovoltaic and 2D Materials industries in global markets** which are strongly dominated by the US and Asian industries, **safeguarding existing jobs in Europe** in high-tech sectors

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MORE INFO

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