

IMM Catania-University Unit

List of facilities & instrumentation

Synthesis and Micro/Nano Fabrication

Growth, deposition, and thermal processes

MBE System

Contact persons: Prof. Antonio Terrasi, antonio.terrasi@dfa.unict.it; Dr. Vincenzina Strano, vincenzina.strano@cnr.it

CLEAN ROOM ISO 5 (100 CLASS)

MBE system for Si, Ge and C deposition on 6" Wafers (DCA)

- Sample holder up to 1100 °C
- 3 e-gun: Si, Ge, SiC for co-deposition
- 5 effusion cells for doping (B, Er, Sb, Ge, As)
- In situ RHEED analysis
- In situ XPS-UPS-Auger analysis, UV lamp, Flood gun for insulators

Synthesis of SiGe quantum wells - Ge quantum dots - Ultrathin doped layers (FWHM 3 nm) - Complex multilayer structures

Magnetron Sputtering 8"

Contact person: Dr Maria Miritello, mariapilar.miritello@cnr.it

AJA Confocal RF-Magnetron Sputtering System

- Up to 3 targets (4 in.), that can be simultaneously and independently used (3 RF and 1 DC power supply)
- UHV chamber (10⁻⁹ mbar)
- Wafers up to 8" up to 800 °C
- 3 gas lines
- Deposition of high purity single element or alloys thin films and multilayers with accurate control of stoichiometry and of elemental content (lower than 0.1 at.%)

Some examples:

- Rare earth oxides and rare earth silicates (i.e. Y₂-xEr_xSi₂O₇)
- Undoped and Eu doped SiOC
- GeSbTe and Ge_{1-x}Te_x alloys
- Ge and Si_{1-x}Gex thin films and quantum dots

- Ti and TiO₂ and Cu₂O
- Transparent Conductive Oxide (AZO, ITO, TZO, Ga₂O₃)
- Transition metal oxides (MoO₃, V₂O₅)

Atomic Layer Deposition

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Atomic layer deposition Picosun™ R-200 Advanced

- Thermal and plasma (remote) ALD
- Deposition on wafers up to 8" and also on powders
- The sample holder can be heated up to 650°C
- The chamber can be heated up to 500°C
- Equipped with quartz balance, RGA

Current materials: TiO₂, ZnO, Al₂O₃, Ag, Ru, Pt, Pd

Chemical Vapour Deposition

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Aixtron-"Black Magic" CVD-PECVD

- Thermal and plasma enhanced CVD
- Gas sources: Ar, H₂, NH₃, CH₄, C₂H₂
- Temperature up to 1000 °C Ramp up to 300 °C/m
- Up to 6" wafer
- Materials: 2D graphene
- 3D graphene based structures
- Carbon nanotubes

Electrochemical station

Contact person: Prof. Antonio Terrasi, antonio.terrasi@dfa.unict.it

CLEAN ROOM ISO 7 (10000 CLASS)

Electrochemical station

Electrochemical deposition, corrosion

Horizontal furnace

Contact person: Prof. Antonio Terrasi, antonio.terrasi@dfa.unict.it

CLEAN ROOM ISO 7 (10000 CLASS)

Horizontal Furnace: the Carbolite horizontal furnace

- Size: 75mm internal diameter x 150 cm long
- Pre-chamber for the introduction of one or more samples loaded into a floating quartz boat (4cm x 9 cm).
- Max temperature: 1500°C.
- Gas lines: N₂, O₂ and Ar or Ar:H₂ forming gas (5%).

- Vacuum: at least 10^{-5} mbar.
- Gas flows: 0-20 lpm (accuracy of about 0.25 lpm).

Optical and laser lithography

The Laboratory is an ISO 5 clean room that includes facilities for Photolithography processes.

The fabrication set consists in a Mask Aligner, with Bottom Side Alignment option and a maximum resolution of 0.4 μm for lines and 0.6 μm for holes, an automatized coating system, with spin coater and hot plate, and a vertical laminar flow wet bench for developing steps.

UV & Nanoimprinting Lithography

Contact person: Prof. Salvatore Mirabella, salvo.mirabella@dfa.unict.it

CLEAN ROOM ISO 5 (100 CLASS)

MJB4 Mask Aligner (from SUSS MicroTec)

The UV lithography system has the following features:

- sample size up to 4" (or 100x100mm) and thickness up to 4 mm;
- Hg 350 W lamp, plus a SUSS Diffraction Reducing Exposure Optics, working in the 350-450 nm wavelength range, with excellent light uniformity on the sample (< 3%). A constant Intensity control is available for the 365 nm or the 405 nm line;
- alignment can be performed through a Splitfield Microscopy equipped with monitor and objective lens (10x and 5x);
- printing modes: contact in soft, hard, vacuum and soft vacuum mode, or proximity printing;
- best resolution tested on Si wafers: 0.4 μm for lines and 0.6 μm for holes.

The system is equipped also with a NIL module, allowing UV printing at the nano-scale level. UV-NIL is a low-cost production technology that is based on UV-curing, developed as a cost-effective alternative to high-resolution e-beam lithography. An easy and fast switching between UV-lithography and UV-NIL allows to combine these processing techniques. UV-NIL can be performed on sample up to 2" in size, with a best resolution of lower than 100 nm.

A spinning system for sample coating with photoresist film, up to 6" sample is available, together also with an hot plate (160x160 mm) up to 325 °C.

Characterization

SCANNING ELECTRON MICROSCOPE

Contact person: Dr. Vincenzina Strano, vincenzina.strano@cnr.it

Technician: C. Percolla, carmelo.percolla@ct.infn.it

30 kV Field Emission Scanning Electron Microscope, Carl Zeiss SUPRA™ 25 with the following specifications:

- Equipped with Xplore30 Energy Dispersive X-Rays (EDX) detector, Oxford Instruments

- Equipped with a Gemini multi-mode scanning Transmission Electron Microscope (STEM) detection system
- Equipped with a Gatan MonoCL4™ system for cathodoluminescence (CL) microscopy
- SEM resolution: 1.7 nm at 15 kV, 3.5 nm at 1 kV
- Acceleration Voltage: 0.5-30 kV
- Probe current: 4 pA-10 nA
- Detectors: High efficiency In-lens detector, Secondary electrons detector, STEM detector, EDX microanalysis detector for imaging/mapping and X-Rays Spectroscopy, CL system for Panchromatic and Monochromatic imaging and Spectroscopy (Spectral response 185- 850 nm)
- Typologies of samples: thin films, powders

ATOMIC FORCE MICROSCOPE

Contact person: Prof. Francesco Ruffino, Francesco.ruffino@ct.infn.it .

Bruker INNOVA Atomic Force Microscopy with the following specifications:

- Closed-Loop Scanner: XY > 90 µm, Z > 7.5 µm
- Open-Loop Scanner: XY > 5 µm, Z > 1.5 µm
- Sample size: X-45 mm x Y-45 mm x Z-18 mm
- Motorized Z Axis Stage: Z Travel: 18mm
- Optics: Camera: on-axis color CCD with motorized zoom
- Field of view: 1.25mm - 0.25mm (motorized zoom, with 10x objective)
- Resolution: <2 µm with standard 10x objective (0.75 µm with 50X)
- Electronics: 20-bit DAC control, 100 kHz $\hat{A}\pm 10$ v ADCs, digital feedback
- System software: SPMLa v7 for data acquisition & analysis
- Equipped to perform conductive measurements
- Typologies of samples: ideal for applications such as surface studies in materials science, characterization of polymers, biomolecules, and semiconductors, and nanomanipulation and nanolithography

Representative papers:

- Applied Surface Science 529 (2020) 147142
- Scientific Reports 8 (2018) 5001
- Superlattices and Microstructures 113 (2018) 430

SCANNING TUNNELLING MICROSCOPE

Contact person: Prof. Francesco Ruffino, Francesco.ruffino@ct.infn.it

Nanosurf easyScan2 STM with the following specifications:

- Maximum Scan Range: 500 nm
- Maximum Z-Range: 200 nm
- Current set point : 0.1-100 nA in 25 pA steps
- Tip voltage: $\hat{A}\pm 10$ V in 5mV steps
- Tip sample approach: Stick-slip piezo motor

- Sample size: max 10 mm diameter
- Modes of operation: constant current mode and constant height mode

PHOTOLUMINESCENCE AND ELECTROLUMINESCENCE

Contact person: Dr. Giorgia Franzò, giorgia.franzo@cnr.it

Home-assembled system for photo- and electro-luminescence measurements on thin films, liquids and powders. It is equipped with different excitation continuum laser sources:

- HeCd (325 nm)
- Solid state laser at 488 nm
- Ti-sapphire (tunable in the wavelength range 700-1000 nm) and different devices for the detection of the luminescence signal
- Hamamatsu photomultiplier tube for the UV and visible region
- Infrared extended Hamamatsu photomultiplier
- Ge detector for the near infrared region (from 800 to 1700 nm)
- Hamamatsu InAs detector and Judson Technologies InSb detector for the infrared region (up to 3500 nm and 5500 nm, respectively)
- A system for time-resolved measurements using an acousto-optic modulator to modulate the laser and a Stanford Research multichannel scaler to acquire the signal with a time resolution of about 30 ns
- A system for time-resolved photoluminescence measurements formed by an optical parametric oscillator (OPO) pumped by a ns Nd:YAG laser, a spectrograph with an intensified CCD and a linear InGaAs detector. With this setup it is possible to measure PL spectra by tuning the excitation wavelength in the 200-2000 nm range and to perform time resolved PL measurements with a time resolution of 10 ns
- An Oxford closed cycle He cryostat for low temperature measurements down to 10 K
- Different power supplies (both continuous and pulsed) for electroluminescence measurements
- Best suited (however, not limited to), due to ultra-decennial expertise, for silicon-based photonics

Representative papers:

- *Advanced Optical Materials* 8 (2020) 2001070
- *RSC Advances* 6 (2016) 73170
- *Applied Physics Express* 7 (2014) 012601

UV-VIS SPECTROPHOTOMETER

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté, giuseppe.pante@ct.infn.it

UV-Vis Spectrophotometer LAMBDA 45 (Perkin Elmer) with the following specifications:

- Equipped with an halogen lamp for measurements in the VIS region and a deuterium lamp for measurements in the UV region
- Operates in a range of 190 - 1100 nm with a resolution of ± 0.1 nm

- Spectroscopic Ellipsometry (SE) A
- The bandwidth is in the range of 0.5 - 4 nm, with a speed scan between 7.5 and 2880 nm/min
- Measurements on liquids samples, regulatory tests requiring variable resolution, and highly light-scattering samples
- An additional pre-monochromator reduces stray light by a factor of 2, providing optimum performance for turbid and light-scattering samples, such as some biological solutions and suspensions
- Can operate in scanning mode, wavelength program, time-drive, rate, quant and scanning quant
- It is particularly suited to investigate the photocatalytic properties of nanostructures by the degradation of organic dyes and DNA/RNA analysis, the detection of biomolecules and to evaluate the concentration of bacterial samples

Representative papers:

- Applied Catalysis B 238 (2018) 509
- Chemical Engineering Journal 379 (2020) 122309
- Scientific Reports 9 (2019) 974

IR SPECTROPHOTOMETER

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté Giuseppe.pante@ct.infn.it

Jasco FT-IR 4700 Spectrophotometer with the following specifications:

- Equipped with ATR-IR accessories
- Equipped for specular reflectance measurements
- Equipped for diffused reflectance measurements

SOLAR SIMULATOR

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté Giuseppe.pante@ct.infn.it

Solar simulator ORIEL LSS-7120 (Newport) with the following specifications:

- Maximum irradiance: 100 mW/cm²
- Independent control of the bands
- Inhomogeneity <2%

Representative papers:

- Materials Science in Semiconductor Processing 112 (2020) 105019
- RSC Advances 9 (2019) 30182

UV-LED LAMP

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté Giuseppe.pante@ct.infn.it

UV-LED LAMP (Uwave) with the following specifications:

- Peak centered at 365 nm
- Irradiance can be changed from 15 to 250 mW/cm²
- Inhomogeneity < 1.8%

Representative papers:

- ACS Applied Bio Materials 3 (2020) 4417
- Materials Science in Semiconductor Processing 118 (2020) 105214

Access to research institutions and industries external to CNR: Yes; Costs (indicative): € 230.

CONTACT ANGLE MEASUREMENT SYSTEM

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté Giuseppe.pante@ct.infn.it

Optical **contact angle measurement system OCA 15PRO (Dataphysics)** with the following specifications:

- Sample table can slide freely in X- and Y-direction and is locked into position with its switchable magnetic base
- In Z-direction the sample table is adjustable using precision mechanics with a hand wheel

Representative papers:

- RSC Advances 8 (2018) 521
- Journal of Photochemistry and Photobiology A 332 (2017) 497

SURFACE AREA AND POROSITY ANALYZER

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté Giuseppe.pante@ct.infn.it

Surface area and porosity analyser Tristar II (Micrometrics) with the following specifications:

- Sample need to be in powder form
- Can measure surface areas as low as 0.01 m²/g
- Accommodates analysis with a variety of adsorbates including argon, carbon dioxide, and other noncorrosive gases such as butane, methane, and other light hydrocarbons

Representative papers:

- Chemical Engineering Journal 379 (2020) 122309
- Journal of Photochemistry and Photobiology A 380 (2019) 111872
- Materials Science in Semiconductor Processing 112 (2020) 105019

TOTAL ORGANIC CARBON ANALISER

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté Giuseppe.pante@ct.infn.it

Total organic carbon analyser **TOC LCSH (Shimadzu)** with the following specifications:

- Equipped with micro-sampling system for the analysis of small volumes of solution

Representative papers:

- Catalysis Today 321-322 (2019) 146
- Journal of Photochemistry and Photobiology A 380 (2019) 111872

- RSC Advances 9 (2019) 30182

ELLIPSOMETER

Contact person: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it

Technician: Giuseppe Panté Giuseppe.pante@ct.infn.it

M-2000 spectroscopic ellipsometer (Woollam) with the following specifications:

- Advanced optical design, wide spectral range, and fast data acquisition
- Measurements cover the spectral range from deep ultraviolet (193 nm) to near infrared (1690 nm)
- The use of a CCD (Charge Coupled Device) detector allows simultaneous measurement of hundreds of wavelengths
- The system is also equipped with an automatic mapping stage, able to automatically mapping films up to 8" in diameter
- It is commonly used to measure thin film thickness and optical constants of materials. It is sensitive to less than a monolayer of material (sub-nm) on a surface

Representative papers:

- Applied Catalysis B 196 (2016) 68
- ACS Applied Bio Materials 3 (2020) 4417
- ACS Applied Materials and Interfaces 10 (2018) 40100

POTENTIOSTAT

Contact person: Prof. Salvatore Mirabella, salvo.mirabella@dfa.unict.it

PAR Potentiostat with the following specifications:

- Possibility of cyclic voltammetry measurements
- Possibility of electrochemical impedance measurements
- Possibility of stripping voltammetry
- Possibility of coulometry

Representative papers:

- International Journal of Hydrogen Energy 162 (2025) 150722
- Scientific Reports (2025) 15:28439
- Sustainable Materials and Technologies 41 (2024) e01097

ZETA POTENTIAL

Contact persons: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it and Dr. Massimo Zimbone, massimo.zimbone@cnr.it

SURPASS 3 STANDARD

- Analizzatore elettrocinetico di alta gamma per l'analisi delle superfici solide
- Analisi del potenziale zeta completamente automatizzata su solidi macroscopici
- Rilevazione automatica del punto isoelettrico
- Registrazione in funzione del tempo delle cinetiche di adsorbimento superfici liquido su solido.

RAMAN AND PHOTOLUMINESCENCE MICROSCOPY

Contact persons: Dr. Giuliana Impellizzeri, giuliana.impellizzeri@ct.infn.it and Dr. Massimo Zimbone, massimo.zimbone@cnr.it

HORIBA HODISSEY

Fully Motorized XYZ Stage

Wavelengths: 320 nm @ 20 mW; 532 nm @ 150 mW

Holographic gratings: 2400 lin/mm; 1800 lin/mm; 600 lin/mm

Optimised Optic for UV

Bandpass filter for ULF Raman

Edge filter for Photoluminescence ($\lambda > 350$ nm)

Objectives: 5x/10x/100x Vis Grade/50x LWD/74x, UV Grade

3-electrodes cell for in operando electrochemical measurements

Supported with a database for unknown material

REFLECTION OPTICAL MICROSCOPY

Contact persons: Dr. Massimo Zimbone, massimo.zimbone@cnr.it; Dr. Vincenzina Strano, vincenzina.strano@cnr.it

Microscope: Zeiss Axio Imager KMAT

Microscope stand Axio Imager.Z2m

Full motorized and fully software-managed; XYZ Mechanical Stage

Contrasts: Bright and dark field reflector module; Polarized light and DIC

Objectives: 5x/10x20x/50x/100x

AMBIENT PRESSURE PHOTO-EMISSION SPECTROSCOPY

Contact person: Maria Miritello, mariapilar.miritello@cnr.it

Technician: Carmelo Percola, carmelo.percola@ct.infn.it

Ambient Pressure Photoemission Spectroscopy APS04 from KP Technology is constituted by a Kelvin Probe system in a Faraday enclosure, equipped with an ultraviolet source for APS measurements and a white source for Surface Photovoltage Spectroscopy. The complete equipment permits to reconstruct the complete materials band diagram by carrying out all measurements in ambient. The system is characterized by the following peculiarities:

- Measurements of contact potential difference by a gold vibrating Kelvin probe, with resolution of 1 - 3 meV
- Ultraviolet excitation source, energy range 3.4 eV to 7.0 eV, that permits to measure the absolute work function of metals and the ionisation potential of semiconductors alongside measurement of the surface Fermi level with the Kelvin probe.
- White source, energy range 1,24 eV - 3 eV, to measure Surface Photovoltage Spectroscopy can be carried also out.

Electrical characterization

BioRad HL5560 specifications:

Minimum carrier density: $2 \times 10^{11} \text{cm}^{-2}$.

Hall Mobility range: $0.1 \div 3 \times 10^3 \text{cm}^2/\text{Vs}$.

Sheet resistance range: $0.5 \div 1 \times 10^5 \Omega/\text{sq}$.

Contact resistance lower than $10^5 \Omega$.

Temperature range: $3.5 \div 500 \text{ K}$.

Low current (10-12 A) to measure very high resistances ($10^{12} \Omega/\text{sq}$).

C-V, IG-VGS, ID-VGS, flat-band voltage, threshold voltage, transconductance, dielectric thickness, doping concentration, effective charges, interface state, defect density, conduction mechanisms, resistivity, mobility, stress induced leakage current, hot carrier injection, effective channel length and width are measured at room temperature by a SUSS PMF8 failure analysis 8" probe station connected to an Agilent 4284A LCR meter and to a Keithley 4200-SCS (Semiconductor Characterization System) configured with two remote PreAmps for low current measurements.

Biology Laboratory

Contact person: Maria-Antonietta Buccheri, mariaantonietta.buccheri@cnr.it

The Biology Lab is equipped to perform microbiology, genetics and genomics analyses.