Research centers on Nano inside Institute AMUTech

Pierre Müller
Professor Aix Marseille University
Director of CINaM
Director of AMUtech
Institute for Advanced Materials and Nanotechnology

Creation in January 2021

Contact: amutech-direction@univ-amu.fr
**Key objective:**

Exalting specific properties at the nanoscale to develop new materials/devices at the meso and macroscopic scales.

**Triptych:** «Understand, fabricate, Innovate»

**Bottom-up approach:** *from fundamental aspects to applications*

<table>
<thead>
<tr>
<th>Physics and chemistry at the nanoscale</th>
<th>Advanced materials</th>
<th>Nanotechnologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals and elementary structures</td>
<td>Assembling</td>
<td>Devices and applications</td>
</tr>
</tbody>
</table>

- Increase the visibility and attractiveness (students, companies) of AMU on materials and nanosciences.
- Promote the synergy between physicists and chemists, academics and industrials.
- Define common objectives for research and training via shared platforms.
- Will to work with society (Humanities and social science).
Research

Physics and chemistry at the nanoscale

Advanced materials

Nanotechnologies

Fundamentals and elementary structures

Assembling

Devices and applications

Molecular chemistry

Supramolecular chemistry

Organic and molecular electronics

Physics of nano-objects

Synthesis, growth, assembling, nanostructuration

Emerging devices

Physics and chemistry of surfaces and interfaces

Nanomaterials

Nano-electronics

Properties at the nanoscale

Metamaterials, Functionnal materials

Nanophotonics

Common research platforms and facilities

Domains and fields of innovation:

Energy, Health, Transport, Communication, Environment, Security and defence
AMUtech gathers 9 laboratories

- Interdisciplinary Center of Nanoscience of Marseille
- Institute of Materials Microelectronics and Nanotechnology of Provence
- Institute of Radical Chemistry
- Institute of Molecular Sciences of Marseille
- Fresnel Institute
- Divided Materials, Interfaces, Reactivity, Electrochemistry
- Center for Theoretical Physics
- Lasers, Plasmas and Photonic Processes Laboratory
- Laboratory of Physics of Ionic and Molecular Interactions

Roughly more than 700 people are working in this domain inside these labs
(the total number of searchers in these labs is greater)
Short presentation of the activities on nano by the AMUtech labs

**CINAM**
Interdisciplinary Center of Nanoscience of Marseille

Physics and chemistry of nanomaterials
- Conception, elaboration, analysis
- Surfaces/Interfaces
- Nano-objects
- Phenomena at the nanoscale
- Local field and local probes

**Imanp**
Institute of Materials Microelectronics and Nanotechnology of Provence

Physics at the nanoscale
- Functional nanostructures & nano-components
- Structure & chemistry of materials
- Detection, radiation and reliability
- Analysis & design of electronic systems

**ICR**
Institute of Radical Chemistry

Explore, control and use the reactivity of radical species.
- Nanostructured organics materials
- Reinforced composite materials
- Nanoparticles nanotoxicity
Short presentation of the activities on nano by the AMUtech lab

Nanophotonics and components
Nanophotonics, nanoplasmamomics, opt antenna
Theory and simulation
Thin film and nanostructuration by Laser
Metamaterials and metasurfaces

Chemical modelling and mechanisms
Surface functionalization
Supramolecular assemblies
Organic lithography
Nanographene
Polyarom. analog
Smart materials

Nanoporous materials for applications
energy, health and the environment:
adsorbents, microbatteries, membranes,
sensors, energy storage, etc.

Divided Materials, Interfaces,
Reactivity, Electrochemistry

Institut Fresnel

Institut of Molecular Sciences of Marseille

MADIREL
Short presentation of the activities on nano by the AMUtech labs

Center for Theoretical Physics

Theory of quantum transport

Laboratory of Physics of Ionic and Molecular Interactions

Gaz, plasmas, ions, atoms, molecules and their interaction with matter
- 2D materials;
- Artificial 2D topological materials (Xenes)
- Functionalization of adsorbed molecules
- Electronic and vibrational spectroscopies

Lasers, Plasmas and Photonic Processes Laboratory

Laser-matter interaction in short and ultra-short pulse mode
- Nanoparticles for theranostics
- Laser techniques for bioprinting
- 3D silicon and dielectric laser writing
- Laser-based technique for (sub)-μm surface structuration
Many technological facilities are associated to these labs

| **ASUR:** | Laser applications (LP3) |
| **CP2M:** | Electronic Microscopy (Chem. Fed.)  
  2 SEM, 1 FIB, 2 TEM |
| **Espace photonique:** | Thin films for optics (Fresnel)  
  Plasma sputtering, ions pulverisation, spectrophotometer… |
| **NanoTecMat:** | Epitaxy Si, Ge (IM2NP)  
  Lithography, RIE, Epitaxy, spectroscopies, FIB… |
| **Planete:** | Clean room for nanofabrication (CINaM)  
  Lithography, deposition magnetron sputtering, reactive ion etching… |
| **RPE platform:** | Electron spin resonance (Chem. Fed.) |
| **Spectropole:** | Nuclear Magnetic Resonance, Mass spectrometry (Chem. Fed.) |

**Completed by several very specific equipments**

- Atomic probe tomography (IM2NP)
- Low Energy Electron Microscopy (CINaM)
Call for projects of AMUtech (for research and training) will focus on two axes, four themes, 17 key words

<table>
<thead>
<tr>
<th></th>
<th>Smart Materials</th>
<th>Optronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy conversion and storage</td>
<td>Capacitors</td>
<td>Nanorectena</td>
</tr>
<tr>
<td></td>
<td>Batteries,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PhotoVoltaics</td>
<td></td>
</tr>
<tr>
<td>Functionality and adaptation</td>
<td>Modified graphene, 2D Covalent networks</td>
<td>Meta surfaces Meta materials</td>
</tr>
<tr>
<td>Detection</td>
<td>Photochemistry</td>
<td>Nanostructured surfaces</td>
</tr>
<tr>
<td></td>
<td>Sensitive chemistry</td>
<td>Plasmonics</td>
</tr>
<tr>
<td>Heterogenous integration</td>
<td>2D Stacking</td>
<td>Electron/photon coupling</td>
</tr>
<tr>
<td></td>
<td>Hybridous Semi conductors</td>
<td>Nanophotonics</td>
</tr>
<tr>
<td></td>
<td>Flexible electronics</td>
<td></td>
</tr>
</tbody>
</table>
## An attempt to give a (partial) overview (by studied objects)

<table>
<thead>
<tr>
<th>Surfaces/interfaces</th>
<th>CINaM</th>
<th>IM2NP</th>
<th>ICR</th>
<th>ISM2</th>
<th>Fresnel</th>
<th>Madirel</th>
<th>LP3</th>
<th>PIIM</th>
<th>CPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic of surf. Functionnalization Nanostructuration</td>
<td>Structure Functionnalization Nanostructuration</td>
<td>Functionnalization</td>
<td>Functionnalization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultrathin films</td>
<td>Ferroic spintronics</td>
<td>Ferroic Spintronics</td>
<td></td>
<td>Thin films for optics</td>
<td>Menbr.</td>
<td>Thin films for optics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2D materials</td>
<td>Graphene, Silicene MoS2,</td>
<td>Graphene</td>
<td>Nanograph Polyraromatics analog.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X’enes</td>
<td></td>
</tr>
<tr>
<td>Nanoparticles</td>
<td>Catalysis Theranostic Natural NP</td>
<td>Quantum dots</td>
<td>Nanoplasmonics</td>
<td>Nanoplasmonics Therano.</td>
<td></td>
<td></td>
<td></td>
<td>Stellar dusts</td>
<td></td>
</tr>
<tr>
<td>Nanowires, Nanotubes</td>
<td>C, Si...</td>
<td>C, Si, Ge...</td>
<td></td>
<td></td>
<td></td>
<td>TiO₂...</td>
<td></td>
<td>Quant. Transp.</td>
<td></td>
</tr>
<tr>
<td>Nanoporous, Nanocompos.</td>
<td>Concrete, For energy</td>
<td>Reinf. Compos.</td>
<td>Metamat</td>
<td>For energy, health...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrumentat.</td>
<td>Local probes</td>
<td>sensors</td>
<td></td>
<td></td>
<td>Sensors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**APPLICATIONS:** Health, Energy, Environment...
<table>
<thead>
<tr>
<th>Property</th>
<th>CINaM</th>
<th>IM2NP</th>
<th>ICR</th>
<th>ISM2</th>
<th>Fresnel</th>
<th>Madirel</th>
<th>LP3</th>
<th>PIIM</th>
<th>CPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase transitions</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Quant. transport</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Spintronics</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opt. prop.</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mech. prop.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vib. prop.</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Therm. prop.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electron. prop.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic prop.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Chem. prop.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactivity</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Photovoltaic.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Simulations</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Training by research

Improve the content of AMU's training courses to reinforce one or all of the following points...

• Enhanced international attractiveness by specific AMUtech scholarships (incoming and outcoming)

• «Training by research»: Immersion of Master's students in AMUtech's interdisciplinary research environment and research internships

• Reinforce the link between masters and phd

• Master class: for international multidisciplinary training (including humanities and social science)

• «Learning by doing»: Easy access to technological platforms development of integrated projects

• Fostering cooperation: especially inside CIVIS
Thank for your attention

(in spite the difficulty of the exercise)

Contact: amutech-direction@univ-amu.fr
Appendix
In these labs, only people working in the field of materials and nanotechnologies are concerned by AMUtech.

<table>
<thead>
<tr>
<th></th>
<th>Staff</th>
<th>PhD and Post doc</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM2NP</td>
<td>154</td>
<td>70</td>
<td>224</td>
</tr>
<tr>
<td>CINaM</td>
<td>94</td>
<td>80</td>
<td>174</td>
</tr>
<tr>
<td>ICR</td>
<td>85</td>
<td>30</td>
<td>115</td>
</tr>
<tr>
<td>ISM2</td>
<td>30</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>Fresnel</td>
<td>27</td>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>Madirel</td>
<td>28</td>
<td>15</td>
<td>43</td>
</tr>
<tr>
<td>CPT</td>
<td>8</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>LP3</td>
<td>10</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>PIIM</td>
<td>20</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>456</strong></td>
<td><strong>264</strong></td>
<td><strong>720</strong></td>
</tr>
</tbody>
</table>
An attempt to give a (partial) overview of strengths (by key words)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Couplage UMR</th>
<th>IM2NP</th>
<th>CINaM</th>
<th>ICR</th>
<th>IF</th>
<th>ISM2</th>
<th>MADIREL</th>
<th>CPT</th>
<th>LP3</th>
<th>PIIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super-condensateurs et micro-batteries</td>
<td>***</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nanophotovoltaïque</td>
<td>**</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nano-rectenna</td>
<td>***</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphène modifié</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Réseaux covalents</td>
<td>***</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Métasurfaces et métamatéraux</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photochromes</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chimie sensitive</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surfaces nanostructurées</td>
<td>***</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nano-plasmonique</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empilements 2D</td>
<td>**</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semi-conducteurs hybrides</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronique flexible</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Couplage électron-photon dans les nano-hétérostructures – Transport quantique</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nanophotonique compatible CMOS</td>
<td>*</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td>⋅</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reinforcement of the visibility of the site through AMUtech's key actions in its fields of expertise

**Increased attractiveness of the site: high level students, national and international experts, visitors**

**Important implementation of multidisciplinarity (physics, chemistry, environment, health, human and social sciences, ...)**

Training/Research/Industry links strengthened through strategic partnerships and long-term policy

Expected increase in the success rate for PPAs, especially European (concept of AMUtech consortium)

Emergence of new flagship themes in teaching and research
The AMU’s training courses related to AMUtech

- Master NanoSciTech (NDQ, IMN, CNE)
- Master Physique
- Département Matériaux Polytech
- Master Chimie (SOCV, ACS)
- Master Instrumentation (MSD)
- Master Ingénierie de la santé

NDQ : Nano-ingénierie et Dispositifs Quantiques
IMN : Ingénierie des Matériaux et Nanotechnologies
CNE : Chemical Nanoengineering
SOCV : Synthèse Organique et Chimie Verte
ACS : Analyse Chimique et Spectroscopie
MSD : Microcapteurs et Systèmes de Détection
Aix-Marseille University institutes

A new dynamic to strengthen the link between training and research

AMUTech will be created on January 2021.
Archéologie Méditerranéenne
Archimède Mathématiques Informatique
Cancer et Immunologie
Créativité et Innovations
Marseille Imaging
Marseille Maladies rares
Mécanique et Ingénierie
Méditerranéen pour la Transition Environnementale
Microbiologie, Bioénergies et Biotechnologie
NeuroMarseille
Physique de l'Univers

Sciences de la Fusion et de l'Instrumentation en Environnements Nucléaires
Sciences de la santé publique d'Aix-Marseille
Institut Sociétés en Mutation en Méditerranée
Towards Human and Social Sciences

**Beyond multidisciplinarity**

**Stimulate transdisciplinarity:**

Multiply the points of view
(Technological, political, european law, social, philosophical, ethical...)

**Researchers:** Fostering HSS and legal participation in projects

**Students:** Integrating SHS and laws dimensions into academic programs

**Society:** coffe-debate associating SHS and laws.

Towards the creation of

*Center for the Study of Nanosciences and Nanotechnologies in Society*