Relationship between macroscopic (physical and mechanical) properties and microscopic structure (including defects) of materials, using experimental and theoretical approaches is the goal of the research in the department. A large variety of materials is under study: metals and alloys, oxides, ceramics, semiconductors, polymers and composites with organic matrix. They are bulk materials, thin films or nanomaterials, some of them being elaborated in the lab. Many of these materials have industrial applications; others are used as model materials for identification of relevant physical parameters for analysis. Tests and chemical/physical characterization methods cover a wide range of techniques at different scales, including national facilities (ESRF, SOLEIL).

Theoretical modelling and numerical simulation activities are very important. Developments are made at different scales, from atomic structure to mesoscopic and macroscopic behaviours showing the complementarity between physics and mechanics and making the link between the two different approaches.

Keywords
- Thin film synthesis, physical properties, plasticity, dynamic behaviour, surface treatments, dislocations, modelling and simulations, metals, oxides, semi-conductors, ceramics, quasi crystals, polymers, high performance composites, green materials, fatigue, durability, damage, non linear mechanics, extreme environments, multi-physic coupling, scale transition.

COLLABORATION
- International: EPFL et PSI (CH), Barcelone et Madrid (SP), Dresde et LBF (D), Lisbonne (P), Kaunas (LTU), Moscou (RU), Salford et Cambridge (UK), Porto Alegre et Brasilia (BRA), Berkeley, Texas Tech et Georgia Tech (USA), LGM (Tun), ENSM et UBC (CAN).

Research Training
- Master *Physics of Materials and Nanostructures*: study of fundamental properties of solids and applications.
- Master *Materials for Renewable Energies*: study of engineering materials for renewable energy production and project management.
- Master *Air and Ground Transportation*: four specializations: aerodynamics, heat, combustion, structure.

Staff
- 13 CNRS researchers
- 58 teacher-researchers
- 60 doctoral students
- 8 post-doctoral students
- 31 engineering, technician and administrative permanent staff
The department is divided into four research groups:

**PPNA - Physics and Properties of Nanostructures**
Activities relate to the relationship between the structure and physical properties (optical, electrical, mechanical, etc.) of nanostructured materials including surfaces, thin films and bulk materials. Recent studies focus on nucleation and growth dynamics of sputter-deposited nanoparticles and thin films, on nanostructuration of dielectric surfaces and oxide thin films for advanced plasmonic and electro-optical applications. Research works also include synthesis and physical properties of nanolamellar compounds known as MAX phases and MXenes.

**SIMAS - Surfaces, Interfaces and Materials under Stress**
New experimental data at nanometric and atomic scales, associated with elemental deformation mechanisms (from dislocation up to delamination), are collected in order to be directly compared with analytical models and atomistic simulation. The relationships between growth parameters, structure/composition and mechanical properties of nanostructured thin films are also studied. The effects of low temperature nitriding (N contents, phase transformation, microstructure evolution) are analyzed. A specific attention is devoted to the evolution of mechanical properties.

**PDP - Physics of Defects and Plasticity**
- **Physics of Dislocations and Plasticity**
The studies are mainly carried out from atomic to microscopic scales, with dislocations as a vector of plastic deformation, in covalent materials (Si, SiC, InSb), metals (Al, Cu, ...), and complex materials (quasicrystals, micro-and nano-composites or MAX phases).
- **Defects and Irradiation-Induced Properties**
Ballistic collisions generated during irradiation induce changes in microstructure associated with defects production (point defects, clusters, dislocations, ...) which are studied in semiconductor thin films and structural materials for future nuclear reactors.

**DAMDU – Damage and Durability**
This group focuses on the mechanical behaviour of materials and structures for the aeronautical industry as well as ground transportation and energy. Experimental approaches and models are developed in order to study durability and safety of structural materials in realistic conditions: thermo-mechanical loadings, moisture, high strain rates, shocks, variable temperatures and aggressive environments, fatigue and oxidation. The purpose is to optimize materials (MAX phases, green materials new generation, intermetallics...) in order to get better properties. Another objective is to study materials close or above their actual limits in order to propose technological solutions for innovation. Studied materials are metallic alloys: Titanium or Nickel based alloys, Aluminums, high strength steels, and polymers and composites: thermoplastics and thermostetting, carbon or vegetal fiber composites.

The general methodology is the following: developments of original experimental devices in partnership with industry to test materials in conditions close to reality and at different scales, microstructural analysis, formulation of constitutive laws, identification, numerical simulations and dialog with experiments, validation in industrial context.