

**Chemical&physical  
properties**

- RAMAN spectroscopy analyser
- FTIR spectrometer
- SEM/EBSD/EDS
- TEM
- XRD

**Thermal properties**

- DSC and TGA devices

**Mechanical properties**

- Tensile strength machine
- Vickers hardness tester
- Ball-on-disc tribometer

Synthesis of nanopowders by Inductively Coupled Plasma and characterization, powder functionalisation, purification and spheroidization of micropowder

Nanostructured materials and nanoparticulate strengthened composites

Laser welding process

**Sample preparation**

- Metallographic laboratory (cutting, polishing, sputtering...)
- High specification glove box for nanopowders
- Planetary ball mill& cube mill
- Safety related to handling of nanopowders

**Plasma analysis**

- OES
- High Speed Camera
- FTIR spectrometer
- In situ sample tracking system

CONTACTS



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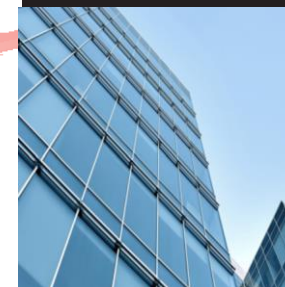


**Empa**

Materials Science and Technology

**NANO - POWDERS**

**Industrial Applications  
Of Nanoparticles**



## TECHNICAL DEVELOPMENT

The ICP Pilot Plant can be used:

- To evaluate nanopowder plasma processing (ceramics, metals, oxides...)
- To spheroidize or to purify micropowder
- To develop innovative in-situ powder functionalisation
- To obtain data that allow to model and simulate the process at industrial scale



## PRODUCT & PROCESS DESCRIPTION

Nanoparticles are particles with a size range defined between 1 to 100 nm. Due to the high surface/volume ratio they possess new and interesting properties (optical, electrical, mechanical...) when compared to the bulk material.



Plasma plume

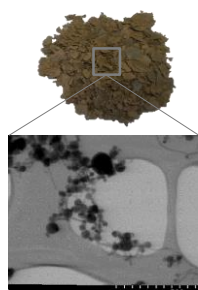
Plasma production of nanoparticles is based on rapid condensation of a supersaturated gas phase. The condensation dynamics influence the nanoparticles properties such as size, size distribution and eventually the final chemical composition. The synthesis is performed under a controlled atmosphere (reducing, oxidizing or inert) and then allows the production of a large variety of nanoparticles.

## COMPETITIVE NANOPOWDERS ...

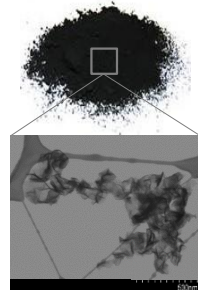
A set of new and interesting properties when compared to the bulk material:

**Mechanical:** incorporating nanoparticles into matrices (polymer, metal or ceramic) can result in improving the mechanical properties, unachievable by using conventional materials and chemicals.

**Optical:** broader absorption range increasing the efficiency of self-cleaning coating (nano-TiO<sub>2</sub>) or the absorption of UV radiation (nano-ZnO).



Silicon nanopowders



Graphene nanopowders

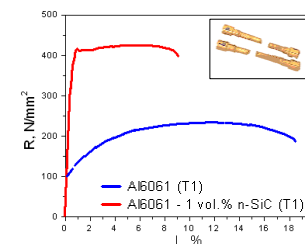
## ... PRODUCED BY ICP

- Large variety of high purity nanopowders (carbides, nitrides, borides, metals, graphene...)
- Starting material mostly commercially available and easy to handle (microscales powders or gas)
- In-situ functionalized nanopowders for better dispersibility or compatibility with matrices
- Decoration of micropowders with nanoparticles (sinterability, catalysts...)

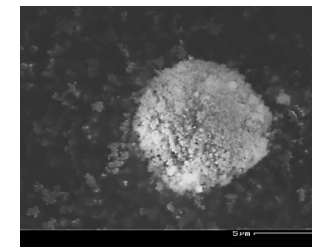
## ACTUAL CAPACITIES

The ICP Pilot Plant can produce between 1 to 30g/h (dependant to the material and parameter settings) of high purity nanoparticles with average size ranging generally from 20 to 50 nm.

Some examples of nanopowders produced by ICP at EMPA: Graphene, Si, Cu, SiC, WC, TaC, VC, ZrC, Al<sub>2</sub>O<sub>3</sub>, WC coated with C, functionalized nano TiCN...



Metal nanocomposite: tensile test curves



μ-particles decorated with nanoparticles

## SERVICES OFFERED

- Demonstration ability of the process
- Market research support
- Support in the scale up process (industrialization with key partners)
- Networking
- High flexibility
- Empa is a multidisciplinary, multicultural research institution on materials