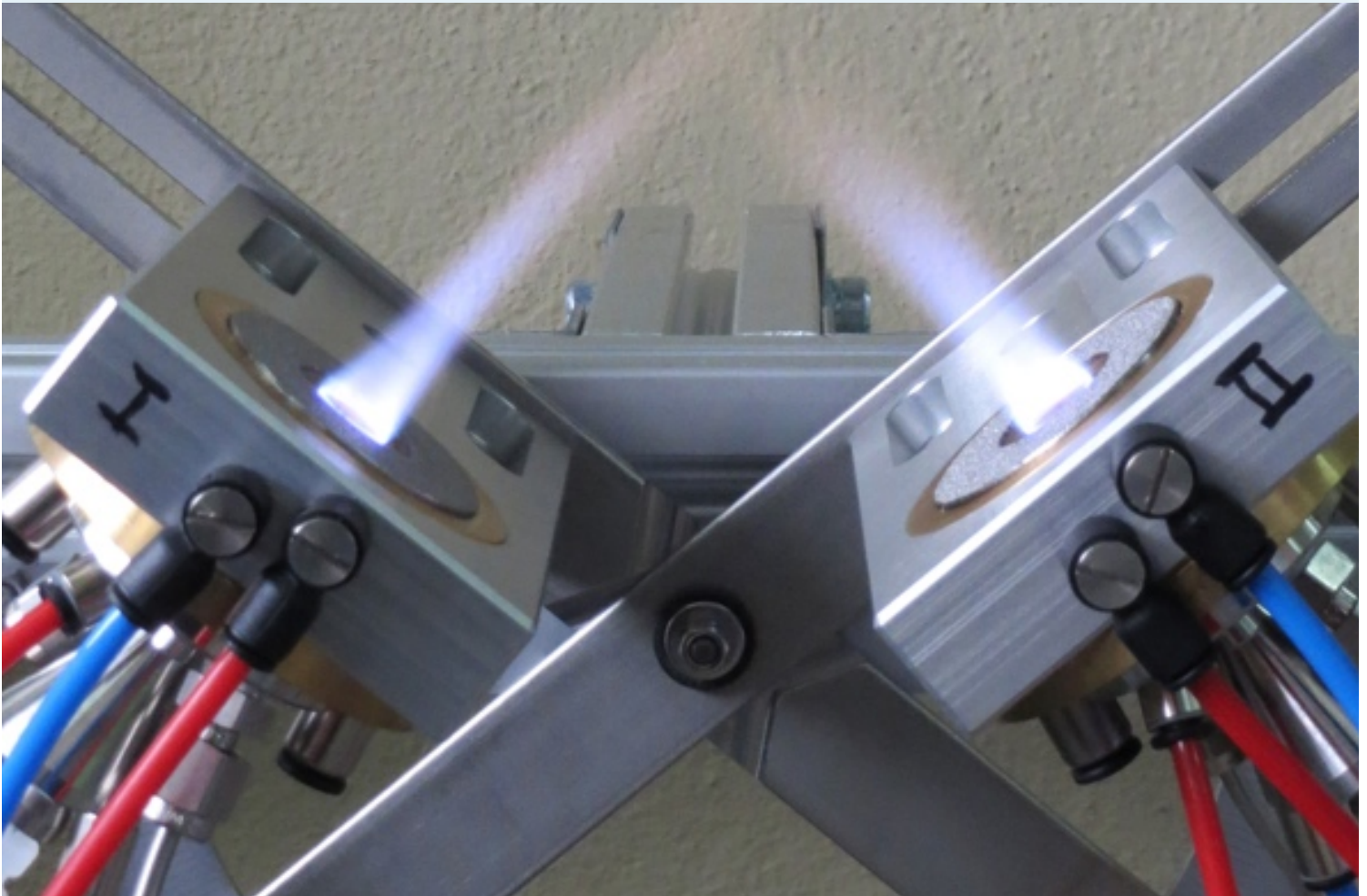


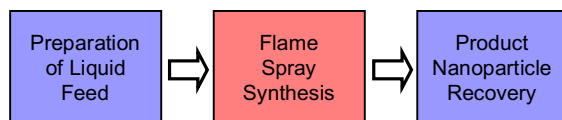
## NANOPARTICLE PRODUCTION by FSP



- ❑ FLAME SPRAY PYROLYSIS (FSP) REACTORS FOR NANOPARTICLE SYNTHESIS
- ❑ TURNKEY LAB-SCALE FSP SYSTEMS
- ❑ PILOT-SCALE UNITS WITH kg/h PRODUCTION RATE
- ❑ NANOPARTICLE PRODUCTION AND DEVELOPMENT SERVICES

## FSP process description

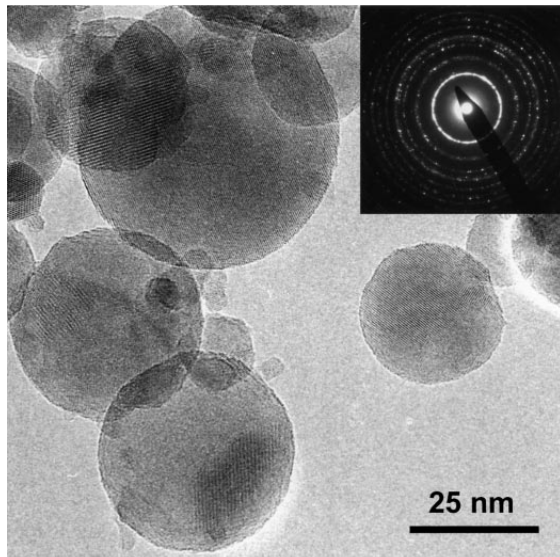
Flame Spray Pyrolysis (FSP) is a versatile and cost-efficient production process for nanoparticles. It relies on the combustion of liquid raw materials containing metal or transition metal compounds at temperatures up to 3000°C. Product nanoparticles are formed within milliseconds and collected as a dry powder on a filter.



The FSP process benefits from an extremely short process chain, enabling the production also of complex nanoparticles in a single step.

## Product Nanopowders

FSP typically produces highly-crystalline oxide nanopowders but phosphates and pure metals have been synthesized as well.



This includes single- and multicomponent oxide nanoparticles as well as noble metal clusters on oxide supports. For some compositions, surface-coated or matrix-

imbedded nanoparticles can be made. A typical particle size range is 10 to 50 nm depending on the process conditions.

Applications of FSP nanoparticles include:

- Catalysts
- Battery materials
- Ceramics
- Pigments
- Dental and biomedical materials
- Gas sensors
- Polymer nanocomposites
- Electroceramics
- ...

## Raw materials

The starting materials for FSP are low-cost metal compounds such as carboxylic acid salts, nitrates, or organometallics. These so-called “precursors” are mixed or dissolved in standard organic solvents (e.g. alcohols, aromatics) that provide the energy for the flame synthesis. Oxygen is required to enable complete combustion.

## The lab-scale FSP reactor

The lab-scale FSP reactor is on the market for about 15 years now and its third generation has been released.



While it now offers improved safety and operational features, the spray nozzle

# ParteQ

geometry has not changed. This allows comparing results to data published in over 100 scientific papers. The lab-scale FSP reactor produces nanopowders at up to 50 g/h.

## Modular concept

The lab-scale FSP reactor is the heart of the nanoparticle synthesis system. Pre-assembled gas-supply modules, liquid precursor delivery pumps and water-cooled filters for collecting gram quantities of product powder are available from ParteQ. It is possible to combine two FSP reactors to a dual system for making even more complex materials or mixing particles at the nanoscale as they are produced.

Further accessories such as tube enclosures, porous wall diluters, quenching rings or spray nozzles for particle surface functionalization are available. With a continuous collection bag-house filter, the lab-scale FSP reactor even turns into a small production unit. All modules can be customized to meet your specific requirements.

## Infrastructure requirements

The FSP reactor only requires oxygen and methane as well as cooling water for operation. You can use your own flow controllers, liquid precursor pump and collection filter if they meet the specifications. Appropriate modules can also be ordered from ParteQ.

The lab-scale FSP reactor must be operated in a ventilated chemical fume hood or similar enclosure. The ventilation off-gas must be filtered to prevent particle release into the environment. ParteQ can also provide fully enclosed and mobile

lab-scale FSP systems with off-gas cleaning by HEPA filters and nanoparticle concentration monitoring.

## Pilot-scale production

Fully automated FSP pilot plants with production capacities up to 5 kg/h have been realized. The units are tailored to the requirements of the customer and delivered as turnkey systems. With process control by PLC the pilot plants are equipped to operate 24/7, allowing small scale industrial production of nanopowders.



## Services

Nanopowder production services at the lab- and pilot-scale are offered by ParteQ as well. Powder batches up to 50 kg can be realized in a short time frame. Based on almost 20 years of experience with flame synthesis of nanoparticles, ParteQ can further assist in nanoparticle synthesis, feasibility and scale-up studies.

