PLASMA PARTICLE TECHNOLOGY
One key focus at the Application Center for Plasma and Photonics of the Fraunhofer Institute for Surface Engineering and Thin Films IST in Göttingen is plasma particle technology. The work here concentrates on the generation or modification of particles and on plasma coating with processing of ultra-fine powders.

The technological basis of the plasma particle technology is predominantly the systems and processes developed at the Application Center. These include:

- Arc-discharge source for the synthesis of carbon nanoparticles
- Atmospheric pressure sputter jet for the synthesis of nanoparticles and for producing coatings
- Low-pressure sputtering system for the all-round coating of micro- and nano-powders
- Plasma reactor for functionalizing powders
- Plasma jet with liquid feeder for processing solutions and dispersions for coating purposes
- Plasma jet with powder delivery system for the secure use of particles for creating coatings

A wide range of materials can be created and processed with the systems available. The spectrum extends from metals via metal oxides, ceramics, and composites to polymer powders.

In addition, the plasma particle technology includes the coating and finishing of objects of the most varied types and geometries – from the thinnest films to complex, three-dimensional structures.

Our offer
- Individual solution concepts
- Feasibility studies
- Prototype production
- Technology transfer
- Advice on the implementation of new product options

1 Variety of materials in plasma particle technology: spherical and flakelike copper particles, copper grit, and cubic tungsten particles (left to right).
PRODUCTION, MODIFICATION, AND INNOVATIVE USE OF PARTICLES

Production of micro- and nano-particles
At the Application Center micro- and nano-particles on the one hand are produced by sputtering various metals with an atmospheric pressure sputter jet. On the other hand, carbon particles are produced by the sublimation of graphite rods in an arc discharge source. The particles can be deposited either directly as nanoclusters on different surfaces or captured for further processing or modification.

Modification of particles
Equipping micro- and nano-particles with specific properties involves treating them with plasma at atmospheric or low pressure. Here, the particle surfaces are equipped with functional groups or coatings and their optical, electrical, magnetic or chemical properties are modified selectively. By functionalizing the surface of particles of precious metals such as gold, it is possible, for example, to optimize wettability by liquids and thus produce stable aqueous dispersions. Furthermore, a coating can improve the flowability and separability of the particles by minimizing not only the mutual cohesion of the individual particles but also their unwanted adhesion to surfaces. This creates the conditions for an optimum processability of particles which are used for plasma spraying processes and in particular in the innovative cold plasma spraying.

Application example: function particles for electrical metrology
In measuring the electrical resistance of objects with a rough surface, such as the electrodes of lithium-ion batteries, it is often impossible to achieve a low-impedance, non-destructive and yet stable contact. Modified particles offer a solution here, and make a reliable acquisition of measured data possible. To measure resistances in, for example, thin battery electrode layers, a new “powder probe” and a measuring set-up were developed at the Application Center. Key components are magnetizable micro particles which are given a highly electrically conductive coating made of silver. By means of a carrier magnet, the particles form a three-dimensional shape with antenna-like structures which locks positively even into complex surface structures and ensures an excellent contact.

Our offer
- Plasma-based particle generation of Au, Ag, Cu, Wo, C, for example
- Plasma coating of particles with carbon and metals such as Ag, Ti, TiN, Al, Cu and Zn
- Functionalization of particle surfaces
COLD PLASMA SPRAYING

The work of the Application Center in the field of plasma coating focuses on plant and process developments that permit to coat in particular thermally sensitive objects. The use of a cold-regulated plasma jet makes this possible. The corresponding technology, cold plasma spraying, is based on processing particles of ultra-fine morphology.

Diversity of coatings
Coatings are produced with a plasma jet into which either liquid particle dispersions or solid powders are introduced. The range of available starting materials here covers several hundred materials including:

- Metals, such as Cu, Al, Ag, Sn, Ti, Wo, Fe, steel
- Metal oxides, such as Al₂O₃, SiO₂
- Plastics, such as PE, PVDF, PTFE

With this process not only track structures can be created but also full-area coatings and gradient layers. In addition, a good depth-going capability means that even complex three-dimensional objects can be coated homogeneously.

Wide range of materials
The classes of materials which can be coated by cold plasma spraying are diverse. A number of examples are given below, including extremely heat sensitive materials:

- Natural materials such as paper, wood, organic-fiber composite materials, cotton
- Polymers such as PA, PE, in particular also on thin polymer films
- Elastomers such as TPE
- Fiber-reinforced composite plastics, including FRP and CRP
- Glass of different types, in particular extremely thin glass
- Ceramics
- Metal foils
- Textiles
COLD PLASMA SPRAYING

Advantages of the technology
Process characteristics of cold plasma spraying are a high deposition rate, the coating speed, and a maximum degree of automation. The technology is thus suitable for the mass production of products. Its advantages over state-of-the-art coating methods comprise:

- No need for binders
- No need for wet-chemical processes
- No additional tools required
- Pretreatment of the substrates is not necessary

Examples of application
Conductor tracks made of high-melting-point metals and anti-static tracks can be applied by cold-plasma spraying to thermally sensitive fibers, fabrics, and plastics. Among other things this opens up innovative approaches to producing intelligent textiles.

The technology can also be used for start metallizations on polymer objects which can be galvanically reinforced in subsequent processes. In this way, conductors can be laid down on injection-molded circuit carriers – so-called MIDs (molded interconnect devices) – without pollutive chemical pretreatment.

In addition, the technology can deliver a diversity of coating functions, such as:

- High thermal conduction
- Reduction in the coefficient of friction
- Antimicrobial functional layers
- Adhesion promotion
- Anti-adhesion
- Barrier layers
- Decorative coatings

Our offer
- Development of individual coating designs and multi-layer systems
- Process development
- Development of system components for specific applications

---

7  Copper-plated door handle with antimicrobial capability.

8  Meandering copper conductor track laid down on paper by cold plasma spraying.
Application Center for Plasma and Photonics of the Fraunhofer IST

The Application Center of the Fraunhofer Institute for Surface Engineering and Thin Films IST in Göttingen aims to harness innovations in modern plasma technology in the fields of the environment, hygiene, health, production, and energy for the benefit not only of industry but also of small and medium-sized companies and to develop tailored concepts for the business sector.

CONTACT

Application Center for Plasma andPhotonics of the Fraunhofer Institute for Surface Engineering and Thin Films IST
Von-Ossietzky-Straße 100
37085 Göttingen

Prof. apl. Prof. Dr. Wolfgang Viöl
Head of the Application Center for Plasma and Photonics
Phone +49 551 3705-218
wolfgang.vioel@ist.fraunhofer.de

Dr. Bernd Schieche
Innovation Manager
Phone +49 551 3705-219
bernd.schieche@ist.fraunhofer.de

http://plasmaundphotonik.fraunhofer.de
www.ist.fraunhofer.de