



1 *Microwave plasma machine (large area).*

PLASMA COATING OF METALS, GLASS AND CERAMICS

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Using PCVD (plasma chemical vapor deposition) coating processes, the surfaces of many different materials can be coated with thin functional layers which significantly improve the characteristics or performance of the parts. Although the coating process has little in common with conventional polymerization processes, as saturated chemical compounds can also be processed, this procedure is called "plasma polymerization".

In this process, gases and substances which easily vaporize under vacuum conditions can be excited by a plasma so as to form a thin layer on the substrates. By this means surfaces with new characteristics are created, which can often not be produced by traditional coating processes:

- Hydrophilic to hydrophobic
- Corrosion resistant
- Wipe-resistant and scratch-resistant

- Low friction
- Semi-permeable
- Biocompatible
- Anti-fingerprint
- Barriers (gases, ions)
- Insulators or spike resistant layers
- Tailored refractive index materials
- Nano-porous adhesion layers

Advantages of plasma processes

- They are environmentally friendly and save resources
- They combine well with other vacuum processes (evaporation coating, sputtering, plasma pre-treatment, plasma cleaning)
- They enable a selective surface coating of thermoplastics



Results

- High deposition rates of up to 20 $\mu\text{m}/\text{min}$
- Large area deposition (0.5 m^2) with a good uniformity of coating thickness ($\sim \pm 10\%$)
- Strong adhesion to most materials even at extreme exposure
- Thermally stable and dense protective coatings
- The coatings are highly transparent ($\sim 96\%$) and clear (0.5-1 % haze)
- High resistance to chemicals (acids, solvents, cleaning agents, petrol, and foodstuffs)
- Temperature strain of the substrate can be kept low e.g. 50-70 degrees/min
- Control of surface tension
- Costs about 10-15 €/m²

This process can meet the fundamental demand for an economical coating process. A laboratory set-up with a coating surface of approx. 0.5 m^2 is available for upscaling of the process.

Applications

Thermally stable corrosion-resistant protective coatings on metals

Corrosion-protection coatings for metal surfaces sensitive to moisture and oxidation were created many decades ago through PCVD coating with siloxanes.

If additional hardness and thermal stability are required, for example protection against oxidation at high temperatures (tarnishing), the application of scratch-resistant coatings is recommended.

To achieve a good adhesion to the metal, a specific plasma pre-treatment should be used, especially in the case of highly oxidation-sensitive metals, e.g. copper or brass. After an appropriate plasma treatment, copper and stainless steel sheets (thickness $\sim 3\text{ mm}$) were coated with PCVD scratch-resistant layers nearly 5 μm thick. After heating at 450 °C for 1 hour, or even longer, they showed neither discoloration nor crack formation and they maintained their hardness. Samples also showed comparatively good bending properties.

Barriers on glass

To protect functional layers on glass, e.g. TCO or photocatalytic TiO_x , against the diffusion of troublesome Na-ions, very dense quartzlike coatings could be applied in very short deposition times by our high rate PCVD process. The operating principle of the linear microwave source, the "plasma line", enables the construction of plasma sources up to 4 m in length. Plasma lines with more than 2 m length have been operating for years in the production of anti-reflective Si_3N_4 -coatings for solar cells.

Insulators on metal and ceramics

The extremely high deposition rates (several $\mu\text{m}/\text{min}$) and the density of the quartz-like coatings make this an economical method of coating metallic and ceramic parts with very thick insulator layers for a high voltage spike resistance, e.g. for piston rings.

Our service offer

- Development of plasma processes to meet customer specifications
- Investigation of specific product characteristics with relevant test procedures
- Comprehensive analysis, professional consultation, literature and patent research
- Upscaling to construction of demonstrators

2 *Stainless steel sheet in the PCVD lab coater (with glass samples to measure film thickness).*

3 *Sheets of copper (left) and stainless steel (right) with corrosion protection coatings after heat treatment (450 °C for 1 hour): Covered, uncoated areas appear oxidized (brown and black color).*