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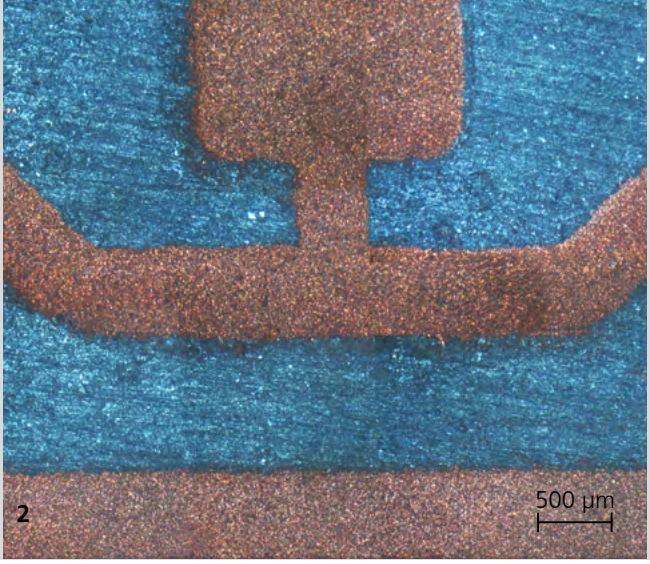


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# COLD PLASMA SPRAYING FOR THREE-DIMENSIONAL MOLDED INTER-CONNECT DEVICES

In many industry sectors, three-dimensional molded interconnect devices (MID) are increasingly gaining in importance. The integration of mechanical, electrical and optical functions into a component enables the miniaturization and rationalization of assembly units. Injection-molded parts are predominantly used as the basis for MID components. Under the keyword "additive mechatronization", the development of new processes, for which the additive generation of mechanical structures is combined with electrical functionalization, is currently being brought to the fore.

## Advantages over conventional metallization processes

For the selective metallization of polymer surfaces, procedures are primarily applied in which galvanic or wet-chemical process steps are necessary. Through prior laser structuring or drying and sintering processes subsequent to the metallization, the process chain for the established procedures is comparatively extensive. Cold plasma spraying, developed at the Fraunhofer IST Application Center for Plasma and Photonics, enables polymer components to be selectively metallized without wet chemistry and without pre- or post-treatment steps. Figures 1 and 2 show sections of such an MID component.

## The technology

The main feature of cold plasma spraying is the utilization of a low-temperature plasma jet, generated from e. g. air or nitrogen. Ultra-fine particles are fed into the process gas and the coating material can be efficiently melted in a low-temperature plasma jet. At the same time the heat transfer to a substrate is minimal. This makes it possible to apply metal coatings to thermally and mechanically sensitive underlays such as polymer and elastomer components, natural materials, such as wood and paper or thin films, without causing damage. The coating is produced without the use of binders. Per passage, layer thicknesses of 5 to 20 µm at a coating speed of approx. 100 mm/s can be realized. The objects are additionally refined under ambient pressure enabling the process to be integrated into more complex inline-capable procedures. Due to the high degree of automation and the kinematic flexibility of robot-aided coating facilities, it is also possible to produce more sophisticated 3D-molded interconnect devices and components (see Figure 1 and 3). This enables the production of a wide range of functional layers for plastics. For example, plastics can be metallized in order to stabilize the substrate or can be equipped with a high electrical or thermal conductivity or antibacterial effect. Further application examples include high current viable coatings, coatings for shielding against electromagnetic interference radiation, flexible conductive tracks, or decorative coatings.

## Advantages of MID components created through cold plasma spraying

An important advantage in the application of cold plasma spraying for the production of MID components is that multi-layer systems can be realized. The possible layer materials encompass the most diverse metals and plastics. The wide range of layer materials also enables the combination of widely varying materials, for example: conductive layers can be equipped with protective layers which prevent degradation under mechanically or chemically onerous environmental


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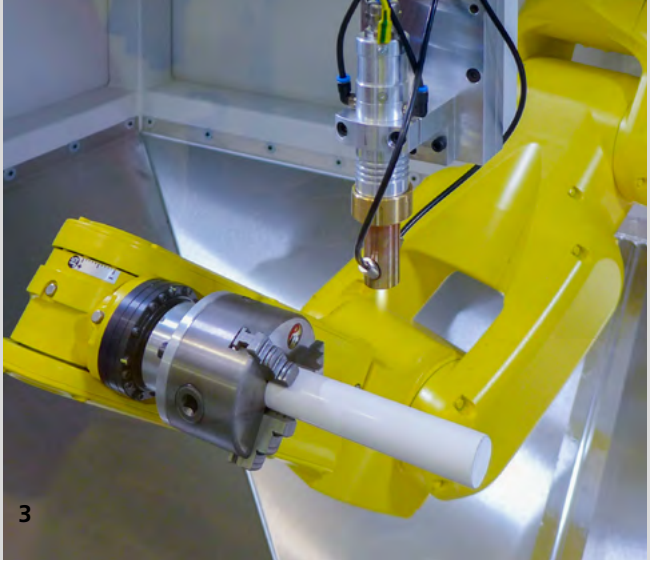

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1 *Copper conductor path structure on an MID component.*

2 *Microscope image of conductor paths with a width of 500 µm.*

3 *Robot-assisted coating process.*

conditions. Bond-promoting primers can also improve layer adhesion. The targeted combination of individual layers also enables the reduction of local layer tensions, e. g. in transition areas between materials with different thermal expansion behavior.

A further advantage is obtained through the utilization of bimodal composite particles: carrier particles can be coated or loaded with a different material. The use of such composite particles enables the reduction of imperfections or oxide phases and therefore improves the mechanical and electrical properties of the layer. Through the utilization of mixed powders, in which differing metals are present as particles, different material properties can be combined with one another.

## Outlook

At the Fraunhofer IST, cold plasma spraying is continuously being further developed in terms of both equipment and procedures. Currently, the focus is being directed on the integration of inline-capable diagnostic systems such as spray-jet and object temperature measurement, on quality assuring analysis methods, such as spatially resolved eddy current measurement, on process optimization in selective metallization with specific masking techniques, and on a combination of 3D printing processes with cold plasma spraying.


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