Improving the Adhesion of Metallic Coatings onto 3D Printed Plastic RF Components

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Adhesion of coatings and metal layers on plastic parts is critical part of numerous industrial processes in the field of microelectronics (PCBs) and communication such as RF components and THz antennas. SWISSto12 has developed a game changing patented technology based on 3D printing that opens a new world of solutions for radio frequency applications. Currently, the metallization of plastic parts requires toxic and complex etching processes to obtain good adhesion. However, we were able to significantly enhance the adhesion of electrolessly plated metals on 3D printed parts by combining our unique processes for grafting polymers on plastic parts with additive manufacturing methods.

"Three-dimensional printing makes it as cheap to create single items as it is to produce thousands and thus undermines economies of scale. It may have as profound an impact on the world as the coming of the factory did… Just as nobody could have predicted the impact of the steam engine in 1750—or the printing press in 1450, or the transistor in 1950—it is impossible to foresee the long-term impact of 3D printing. But the technology is coming, and it is likely to disrupt every field it touches [1]."

Through polymer metallization, the specific properties of 3D-printed plastic and polymeric parts, such as light weight, design flexibility and complexity are enriched by the addition of properties usually associated with metals such as reflectivity, abrasion resistance, electrical conductivity and a variety of decorative effects [2]. Electroless or chemical plating has emerged as a low-cost tool enabling the production of high quality samples at room temperature, especially suitable for polymeric substrates, which would not withstand the high temperature required for vapor deposition strategies [3].

When the metallization of polymer substrates is required, the mechanical cohesion between the deposited film and the substrate (adhesion) is a significant challenge. Current methods include mechanical roughening of the surface, which is not adapted for the kind of complex design, small shapes and high-resolution features available thanks to 3D printing, or chemical etching, usually with a chromium-based etchant. The latter produces large amounts of highly toxic waste and is not always efficient on certain types of 3D printed polymers. Moreover, because of the future European ban on chromium wastes, that efficient process needs to be replaced.

We have developed a process based on the covalent grafting of an interfacial polyelectrolyte layer between the plastic surface and the metal layer, replacing the rough interface obtained by usual pretreatments methods (*e.g.,* chromic acid treatment or mechanical roughening). The process uses the *in-situ* formation of catalytic nanoparticles and increases the final adhesion between the plastic surface and the final metal layer through interdigitation between the materials. Figure 1 schematizes the principle of our method. The process is versatile, based on insertion chemistry activated by heat or UV light. [4]

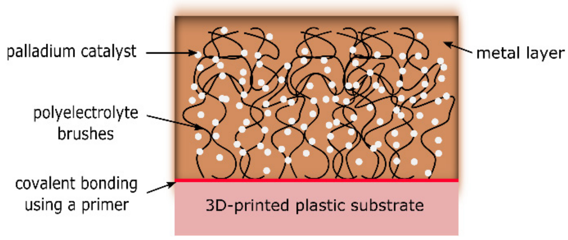

Figure 1: Surface preparation by covalent binding of polyelectrolytes onto 3D-printed plastics and subsequent metallization by electroless plating.

The results obtained on a sample printed with high resolution stereolithography (SLA) are shown in Figure 2.

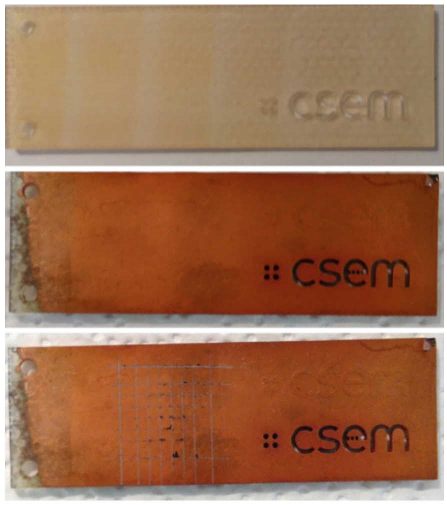

Figure 2: (top) 3D printed plastic sample by stereolithography (SLA); (middle) the same sample after the metallization process; (bottom) the same sample after the adhesion test.

High resolution, smooth, and complex 3D surfaces can thus be metallized with very high adhesion and the process is compatible with a wide range of plastic surfaces. The process is currently tested on the complex 3D shapes of RF components and validated for the wide temperature range over which it needs to operate.

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• SWISSto12 SA, Renens, Switzerland www.swissto12.com

[1] The Economist, Leader, February 10th, 2011.

[2] A. Garcia, T. Berthelot, P. Viel, A. Mesnage, P. Jégou, F. Nekelson, S. Roussel, S. Palacin, "ABS Polymer Electroless Plating through a One-Step Poly(acrylic acid) Covalent Grafting" Appl. Mater. Interfaces 2 (2010) 1177.

[3] O. Azzaroni, Z. Zheng, Z. Yang, W. T. S. Huck, "Polyelectrolyte Brushes as Efficient Ultrathin Platforms for Site-Selective Copper Electroless Deposition" Langmuir 22 (2006) 6730.

[4] Patent filed during the Innosuisse collaboration with SWISSto12.