

We are pleased to introduce you to Fraunhofer TechFlash - Fraunhofer's Flash News on latest and exciting technologies. This TechFlash is about a novel way, >>LaStrADA<<, of pretreatment of Plastic components prior to their Metallization.

The Sustainable Future of Polymer Metallization

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, specializing in Adhesive Bonding Technology, Surfaces, Shaping, and Functional Materials. With its HQ in Bremen and a major branch lab in Dresden, along with specialized centres in Stade, Wolfsburg, Braunschweig, Helgoland, and Cuxhaven, covers the entire value chain, from material design to industrial-scale pilot production.

The Industry Challenge: Currently, the pretreatment of plastics (such as ABS or PC/ABS) prior to their metallization relies heavily on wet-chemical etching involving Chromium compounds mostly followed by wet-chemical seeding with Palladium. While effective, these processes face severe regulatory pressure (such as EU REACH regulations) due to their toxicity and high time and cost demands. For Indian product manufacturer & service provider exporters, maintaining traditional lines poses a risk to international market access, alongside rising costs for wastewater treatment and hazardous waste disposal.

The Fraunhofer Solution: Approach >>LaStrADA<<: Fraunhofer IFAM's LaStrADA project introduces a breakthrough innovative alternative that combines Laser Technology and Physical Vapor Deposition by Atmospheric Pressure Plasma. This method moves the polymer pretreatment prior to the metallization from a wet to a completely dry, inline-capable, on-demand selective/local process.

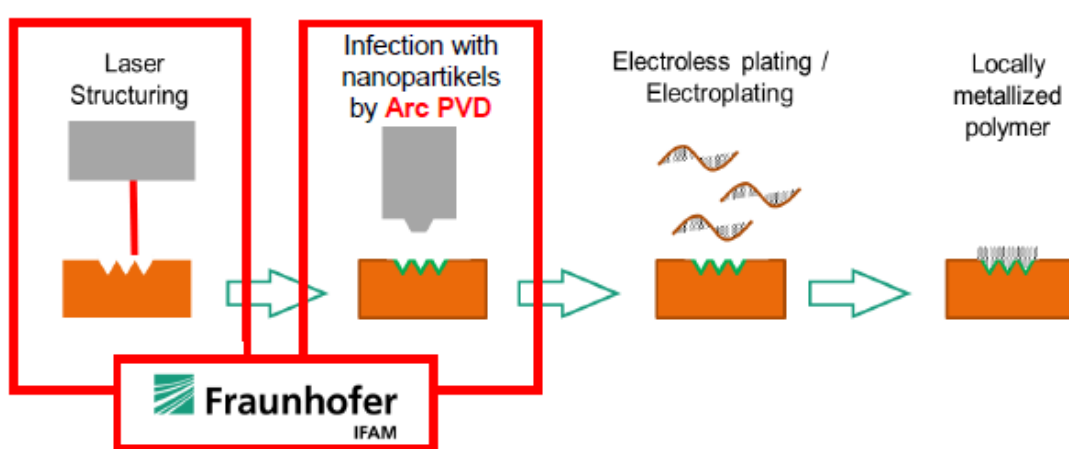
Current Traditional Approach: The polymer metallization process usually starts with wet chemical etching, in which Hexavalent Chromium (Cr-VI), specifically Chromic Acid or Sulfuric Acid, is primarily used in the Plating on Plastics. The ABS (Acrylonitrile Butadiene Styrene) parts are dipped into the hot solution where Hexavalent Chromium (Cr-VI) selectively attacks and dissolves the Butadiene particles on the surface of the plastic. This leaves behind microscopic pits (craters). These pits provide mechanical interlocking, allowing subsequent layers of metal (like Nickel or Copper or Silver) by plating process to bond firmly to the otherwise slippery plastic surface.

Transition to Chromium-Free Etchants:

There are several entirely Chromium-free processes for plastic metallization. While the shift from Hexavalent to Trivalent Chromium is a significant safety upgrade, it still leaves the industry dependent on Chromium. If a company wants to keep their existing electroplating infrastructure but remove Chromium, they switch the Etching stage. The toxic Chromic Acid bath is replaced with a Permanganate-based (Mn-VII) solution. Companies like MacDermid Enthone (with their evolve™ system) and Atotech offer these commercial Chrome-Free Etch (CFE) lines. It works on standard ABS plastic, but the waste is much easier to treat than Chromium. The Indian industry has faced significant pressure from both, the Central Pollution Control Board (CPCB) and global export standards (like REACH and RoHS). Larger Indian Tier-1 automotive suppliers are increasingly adopting Manganese-based etching systems away from Chromium-based. These use Mn-VII or Mn-II compounds to create the same surface roughness on ABS without the carcinogenic risks of Cr-VI. While more expensive to maintain, they eliminate the Cr-VI bath entirely. As etching is the first step, the final chrome look is also shifting. Indian giants like Maruti Suzuki and Tata Motors have mandated a move from Hexavalent to Trivalent Chromium (Cr-III) plating. This shift forces the entire supply chain to upgrade their wastewater treatment plants (ETP) to handle different chemical profiles, often leading them to modernize their etching stages simultaneously.

Fraunhofer IFAM's Forte: The Dry Revolution, Laser & Atmospheric Pressure Plasma Enhanced PVD:

Fraunhofer Innovative solution highlights completely dry, inline-capable LaStrADA process which uses Laser technique to roughen the surface and pulsed arc-like Atmospheric Pressure Plasma discharge to deposit catalytic metal nanoparticles, e.g. Copper, Silver, etc. This eliminates the need for any chemical etching (no Chromium, no Manganese) and the Palladium activator bath altogether.



1. **Laser Structuring for Precise Adhesion:** Instead of chemical etching, high-precision lasers are used to create micro-structures on the polymer surface. This provides the necessary mechanical interlocking and increases the surface area, ensuring the metal layer adheres with industrial-grade strength.

2. **Plasma-Driven Nanoparticle Seeding:** Using an Atmospheric Pressure Plasma process, the system deposits catalytically active metal nanoparticles directly onto the laser-structured surface. This seeding acts as the catalyst for subsequent electroless metallization, eliminating the need for expensive and environmentally harmful activator baths.

In this novel way, the currently harmful polymer pretreatment steps prior to the metallization can be replaced by completely dry, inline-capable and environmentally friendly processes, keeping the following metallization process chain untouched for easy industrial implementation. Moreover, if needed, the pretreatment can be easily carried out selective/local without the time-consuming masking before and unmasking afterwards.

Key Benefits for Indian Industries include:

- By eliminating Chromium, Indian manufacturers can seamlessly meet the stringent environmental standards of European and North American OEMs, securing a spot in global supply chains.
- The process allows for the use of more affordable metals like Copper or Silver as seeds instead of relying solely on expensive Palladium. Furthermore, the removal of wastewater treatment infrastructure significantly reduces CAPEX and OPEX.
- Industry 4.0 Integration - Unlike batch-based wet-chemical tanks, the Plasma-Laser combination is inline production-capable. It can be integrated directly into automated production lines, enabling real-time quality control and faster cycle times.
- The technology supports selective metallization, allowing for the creation of conductor tracks directly on 3D-shaped plastic parts (Mechatronic Integrated Devices - MID), reducing the weight and complexity of electronic assemblies.



Image: Left - Laser-structured ABS substrates, seeded with Palladium (Pd) nanoparticles and Nickel-plated, Right - Laser-structured ABS substrates, seeded with Silver (Ag) nanoparticles and Copper-plated.

While India has a very mature ecosystem for Laser and Plasma technologies as separate industries, the specific hybrid integration, using lasers for micro-structuring followed by atmospheric pressure plasma for chemical-free nanoparticle seeding, remains a specialized competency of Fraunhofer IFAM. Indian industries are highly proficient in the individual components of the LaStrADA process, but they typically apply them for different purposes.

Reference: Fraunhofer IFAM [<https://www.ifam.fraunhofer.de/en/magazine/preparation-polymers-metallization.html>]

Yes, I am interested

About Fraunhofer-Gesellschaft:

Founded in 1949, the Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. It offers contract-based R&D services for specific industry demand, application-oriented technology development from proof-of-principle up to market-readiness across the value chain and offers technical consultancy and feasibility studies to nearly all the industry sectors. The Fraunhofer-Gesellschaft currently operates 75 institutes and research units throughout Germany. Over 32000 employees, predominantly scientists and engineers, work with an annual research budget of €3.6 billion. Fraunhofer generates €3.1 billion of this from contract research. Our global footprint is very strong, with offices and research centres in the USA, Europe and Asia. Fraunhofer has been a long-time trusted innovation partner in India, collaborating with some of the major players in the fields of Material Science, Energy, Environment, Automotive, Electro-mobility, Production Technology, Microsystems and Smart Cities, working with Industry, Government and Public Sector.

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