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Atmospheric-pressure microwave plasma system for cleaning and deposition

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Current wet chemical processes for cleaning and painting of metal surfaces require multiple steps including cleaning, degreasing, deoxidizing and anodizing/chemical conversion coating to impart the necessary surface modification all while using chemicals with significant environmental and health hazards. The most common alternative surface modification methods are laser and plasma-based systems. Plasma systems show promise because a single pass can perform both the surface cleaning and the pretreatment of the metal. The development of a single pass, corrosives-free process for both cleaning and pretreatment of metal surfaces requires a simple but robust process. Atmospheric plasma meets these requirements as it can sequentially clean surfaces, provide surface activation for bond formation, and deposit thin film coatings.

The Center for Plasma Material Interaction (CPMI) at University of Illinois has developed novel patented technologies of Evaporative Coatings at Atmosphere Pressure (ECAP). This atmospheric plasma-based system is designed to eliminate chemical waste and remove contaminants using a microwave plasma. The experiments conducted using this system have showed that that it can effectively clean the aluminum surface from heavy oil contamination. Contact angle measurements, XPS and ATR-FTIR techniques were involved to show the cleaning and activation effect of our system. EM field simulations and gas flow modeling were used to predict and set the experimental conditions. With this setup, treatment time under a minute and 400-600 W power is enough to sufficiently clean the aluminum surface. For example, an aluminum sample contaminated with oil layer had a contact angle of 65.02°±0.49°. After a 30 s plasma treatment in Air using 600 W microwave power and distance of 0.45" from the plasma torch, the contact angle decreased to 8.86°±0.06° indicating the contamination removal while making the surface hydrophilic.

A design reiteration of the old system enables an effective coating deposition in addition to the cleaning and activation processes. This allows for deposition of protective and anticorrosive layers using precursors commonly used in ALD and CVD application. Depositions can also be conducted via Cathodic arc deposition technique (or Arc-PVD) enabled by biasing the target filament with HiPIMS.

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