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Atmospheric-Pressure Low-Temperature Plasma for Thin Film Deposition on Metallic Substrates

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This talk focuses on the development and application of atmospheric-pressure low-temperature plasma jet/jet arrays for thin film deposition on metallic substrates. Different structure of plasma jet including single plasma jet, linear jet arrays and porous jet arrays were developed to achieve uniform film deposition on planar substrate, inner or external tubing surface. The influence of critical parameters, including substrate temperature, bias voltage, and plasma jet configurations, on film growth, adhesion, and microstructure has been studied to achieve precise control of film properties.

Using the atmospheric pressure plasma jet system illustrated in Figure 1, SiOx thin films were successfully deposited on aluminum substrates[1] and steel surfaces[2]. A systematic investigation of substrate temperature effects on film properties was conducted. As shown in Figure 2, increasing substrate temperature led to a morphological transition from island-like structures to elongated spine-like structures. Additionally, surface roughness exhibited a decreasing trend with rising deposition temperature. The uniformity characteristics of linear plasma jet arrays were also examined. Upon increasing the pulse repetition frequency, the ionized gas flow evolved from laminar to turbulent regime, stabilizing at approximately 1.5 kHz. [3]

Furthermore, SiOx thin films were deposited on cylindrical substrates utilizing a radially arranged plasma jet array driven by an AC power source. Comprehensive characterization of the films, including surface morphology, thickness, elemental composition, and chemical structure, revealed that the films primarily consisted of Si–O–Si network structures, with minor contributions from Si–OH groups and inorganic groups such as $–CH_2$ and $Si–CH_3$.[4]

From an application standpoint, SiO_2 coatings have been deposited on GIL components to improve electrical insulation, while Cr_2O_3 coatings have been applied to the inner walls of small-diameter pipelines to enhance corrosion and wear resistance. These findings provide valuable insights into plasma film deposition techniques and their potential for industrial applications.

References

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[3] R. Wang et al, Physics of Plasmas, 2017, 24(9):093507.
[4] R. Wang et al, Surface and Coatings Technology, Volume 437, 2022, 128365.

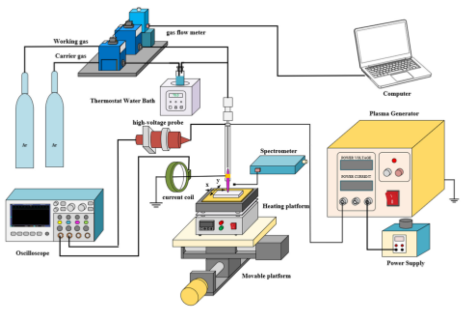

Figure 1. Schematic diagram of the film deposition system by plasma process.

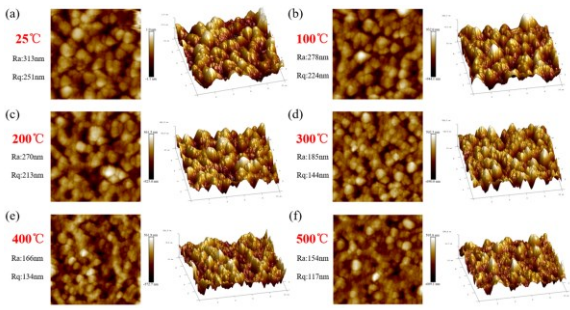

Figure 2. The AFM of films prepared at different substrate temperatures.

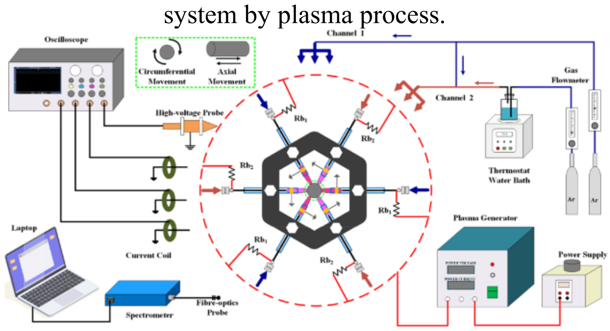

Figure 3. The schematic diagram of the radial plasma jet array system.

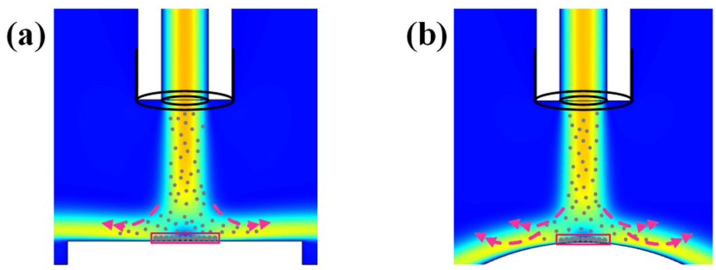

Figure 4. Plasma airflow diffusion model: (a) flat substrate and (b) cylindrical substrate.