Seminar

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Institute for Plasma Research

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Title: Superhydrophobic surfaces developed through argon plasma processing for self-cleaning and water harvesting technologies

Speaker: Mr. Vivek Pachchigar

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Venue: Seminar Hall, IPR

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Abstract

In recent years, the fabrication of superhydrophobic materials with unique functional properties such as self-cleaning, anti-icing, anti-fogging, oil-water separation, water harvesting, omnibhobicity, oleophobicity, etc. have been a trending research interest among researchers. These materials exhibit excellent water repellency due to which they are suitable for a variety of industrial applications. Plasma-based methods (ion beam irradiation, plasma etching, and physical vapor deposition) to achieve superhydrophobicity have received great attention due to their ability for large-scale production, fast processing, environmentally friendly nature and ease of tuning the experimental parameters.

In the present work, argon plasma processing techniques have been used to produce superhydrophobic polytetrafluoroethylene (PTFE or Teflon), and copper surfaces which can be used for self-cleaning and water harvesting technologies, respectively. Firstly, a systematic static and dynamic wettability studies were carried out on the PTFE surface using low energy Ar ion beam. The effect of various ion beam parameters such as ion energy, ion dose, and angle of incidence was investigated in view of producing a superhydrophobic surface for self-cleaning applications [1,2]. In contrast to this, when the PTFE-like thin film is irradiated with 800 eV ion beam, ripple-like nanopatterns with a wavelength of about 212 nm form on the surface as compared to freely standing structures produced in the direction of ion beam in bulk PTFE. Due to the formation of these anisotropic structures, the contact angles also showed 12° of anisotropy along, and across the ripple pattern directions [3]. Radiofrequency (RF) Ar plasma etching process was used on the PTFE surface for producing an industrial-scale superhydrophobic surface. The influence of RF power, treatment duration, impurity, and surface temperature on Ar plasma-treated PTFE was studied [4]. Further, the effect of plasma processing on the wettability of copper surfaces was investigated for the development of an efficient water harvesting device. The process was optimized in terms of type of condensation on the surface, water collection rate, and durability of the surface. After plasma processing, the water contact angle of the copper surface systematically increased to values ranging from 132° to 156°. Moist air condensation experiments were carried out on both pristine and plasma-treated copper surfaces using an in-house water harvesting device. A significant improvement in water collection rate was observed for the plasma processed surface (1305 ml/m^2/hr) compared to the pristine surface (369 ml/m^2/hr). Hence, the results demonstrate the potential of plasma processing techniques for various wettability-related applications, such as self-cleaning and water harvesting.

References:

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[2] V. Pachchigar, M. Ranjan, K.P. Sooraj, S. Augustine, D. Kumawat, K. Tahiliani, S. Mukherjee, Self-cleaning and bouncing behaviour of ion irradiation produced nanostructured superhydrophobic PTFE surfaces, *Surf. Coatings Technol.* 420 (**2021**) 127331.

[3] V. Pachchigar, B. K. Parida, S. Augustine, S. Hans, M. Saini, K. P. Sooraj, M. Ranjan, Comparative wettability study of bulk PTFE and PVD-grown PTFE thin film after low energy ion irradiation, *Thin Solid Films*, 777 (**2023**) 139888.

[4] V. Pachchigar, U.K. Gaur, A. T. V., S. K. P., S. Hans, S.K. Srivastava, M. Ranjan, Hydrophobic to superhydrophobic and hydrophilic transitions of Ar plasma-nanostructured PTFE surfaces, *Plasma Process. Polym.* (**2022**) e2200037.