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Tuning the wettability of metallic surfaces by microwave plasma generated low energy noble gas ion beams

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Metallic thin films of Cu have been irradiated with different inert gas ions (Ar^+, Kr^+, Ne^+) generated by an intense microwave plasma, in order to look at the changes in wetting behaviour of such irradiated films. Special attention is devoted to look at the static contact angle and contact angle hysteresis. Observations reveal an increasing trend of static, advancing and receding contact angles, indicating that the irradiation process precipitates a reduction in surface free energy which has been related to a change in dispersive intermolecular interaction due to implantation of noble gaseous elements with varying polarizability. The nanoscale roughness generated by this process has no impact on the static contact angle. However, the nominal hysteresis created may be attributed to the roughness according to Johanny-de Gennes theory.

1. Introduction:

Wettability is an important surface phenomena of a solid surface that is determined by the adhesive intermolecular forces between a solid and the liquid in contact [1]. Where there are conventional ways to tune wettability by engineering the surface roughness (the Wenzel regime), chemical texturing (Cassie- Baxter regime), and coating or by forming functionalized chemical groups, the present study looks at the possibility of controlling wetting behaviour of metallic surfaces (Cu) by implantation of inert gas molecules (Ar^+, Kr^+, Ne^+) in the near surface atomic layers. Since inert gas molecules do not form any chemical bond with metal, the system thus formed is heterogeneous in atomic length scales and hence has been termed as "atomically heterogeneous" system.

2. Experimental :

An intense microwave plasma based low energy ion source has been developed and employed in the experiment [2]. The wetting property has been characterised by contact angle and it has been measured by sessile drop method. The surface roughness is characterised by RMS roughness which is obtained by Atomic Force Microscopy (AFM) studies.

2.2. Results and discussions:

Figure 1 shows the variation of static contact angle of de-ionised water on Cu substrates irradiated with different ion beam species. It is observed that the substrate undergoes a transition from hydrophilic to hydrophobic nature indicating a reduction in surface energy.

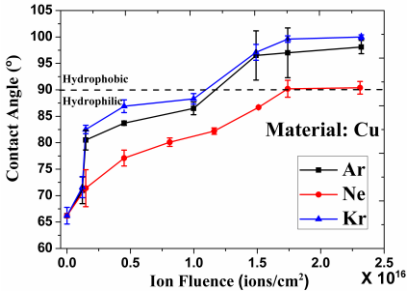

Fig. 1: Variation of water contact angle with fluence for different ion species

It is believed that the dispersive intermolecular force between the metal atoms is perturbed by the presence of inert gas molecule. The resultant surface energy is dictated by the polarizability of the implanted species. However, for real surfaces, the definition of a static, equilibrium contact angle is not unique and the possible values of contact angles are found to lie between the advancing and receding contact angles. We found that both these angles increase with beam fluence and a nominal hysteresis is induced by this process. AFM studies reveal that nanomeric rough surfaces are developed by the irradiation process, which has very little impact on the static contact angle, however, it is responsible for the nominal hysteresis according to the Johanny-de Gennes theory [3]. The details of the analysis will be presented in the conference.

3. References

[1] P.G. de Gennes., Rev. Mod. Phys. **57,** (1985) 827.

[2] A. Chowdhury and S. Bhattacharjee, J Phys. D: Appl Phys, **46**, (2013) 435304.

[3] J. F. Johanny and P. G. de Gennes, J. Chem. Phys, 81, (1984), 1.