World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:13, No:03, 2019

Study of Ion Density Distribution and Sheath Thickness in Warm Electronegative Plasma

Authors : Rajat Dhawan, Hitendra K. Malik

Abstract : Electronegative plasmas comprising electrons, positive ions, and negative ions are advantageous for their expanding applications in industries. In plasma cleaning, plasma etching, and plasma deposition process, electronegative plasmas are preferred because of relatively less potential developed on the surface of the material under investigation. Also, the presence of negative ions avoid the irregularity in etching shapes and also enhance the material working during the fabrication process. The interaction of metallic conducting surface with plasma becomes mandatory to understand these applications. A metallic conducting probe immersed in a plasma results in the formation of a thin layer of charged species around the probe called as a sheath. The density of the ions embedded on the surface of the material and the sheath thickness are the important parameters for the surface-plasma interaction. Sheath thickness will give rise to the information of affected plasma region due to conducting surface/probe. The knowledge of the density of ions in the sheath region is advantageous in plasma nitriding, and their temperature is equally important as it strongly influences the thickness of the modified layer during surface plasma interaction. In the present work, we considered a negatively biased metallic probe immersed in a warm electronegative plasma. For this system, we adopted the continuity equation and momentum transfer equation for both the positive and negative ions, whereas electrons are described by Boltzmann distribution. Finally, we use the Poisson's equation. Here, we assumed the spherical geometry for small probe radius. Poisson's equation reveals the behaviour of potential surrounding a conducting metallic probe along with the use of the continuity and momentum transfer equations, with the help of proper boundary conditions. In turn, it gives rise to the information about the density profile of charged species and most importantly the thickness of the sheath. By keeping in mind, the well-known Bohm-Sheath criterion, all calculations are done. We found that positive ion density decreases with an increase in positive ion temperature, whereas it increases with the higher temperature of the negative ions. Positive ion density decreases as we move away from the center of the probe and is found to show a discontinuity at a particular distance from the center of the probe. The distance where discontinuity occurs is designated as sheath edge, i.e., the point where sheath ends. These results are beneficial for industrial applications, as the density of ions embedded on material surface is strongly affected by the temperature of plasma species. It has a drastic influence on the surface properties, i.e., the hardness, corrosion resistance, etc. of the materials.

Keywords : electronegative plasmas, plasma surface interaction positive ion density, sheath thickness
Conference Title : ICPSI 2019 : International Conference on Plasma Surface Interactions
Conference Location : Prague, Czechia
Conference Dates : March 21-22, 2019