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Measuring negative ion yield and work function from phosphorus doped diamond, boron doped diamond, and graphite in deuterium plasmas

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Negative-ion sources are of considerable interest for applications such as materials processing and neutral beam injection for magnetic confinement fusion. The efficient production of negative ions in these sources often relies on surface production in which positive ions from the plasma bombard the surface, capture electrons and backscatter as negative ions. Alternatively, the positive ions can be adsorbed onto the surface and subsequently sputtered as negative ions. The exposure of these surfaces to plasma at various temperatures modifies their surface state and hence, their ability to produce negative ions.

In this study, a mass spectrometer is used to measure negative ion counts according to their energy and mass from micro-crystalline diamond (MCD), phosphorus doped diamond (PDD), boron doped diamond (BDD), and highly oriented pyrolytic graphite (HOPG) samples at varying temperature under deuterium plasma exposure (150 W, 2 Pa). Angle resolved measurement are also performed to detect negative ions at a high scattering angle from the surface. Magnetized retarding field energy analyser (MRFEA) measurements of negative ion current from HOPG and BDD display the same trends as negative ion counts from mass spectrometry. The surface bias of the samples varies the incident positive ion bombardment energy on the sample and allows for self-extraction of the negative ions toward the diagnostic. We use photoemission yield spectroscopy (PYS) to determine the varying work function of each surface under plasma exposure and its effect on negative ion production. Figure 1 shows that the increasing work function of the plasma exposed HOPG occurs over the same sample temperature range as the decreasing negative-ion counts showing that, as expected, the work function is primarily influencing surface ionization yield. In contrast, the work function of diamond does not show a clear relationship with negative-ion counts, suggesting that different mechanisms influence the negative-ion production

of metal-like HOPG and dielectric-like diamond. It can however be seen from figure 2 that the doping of diamond has a significant effect on both the absolute value of the work function and its variation with temperature under plasma exposure.

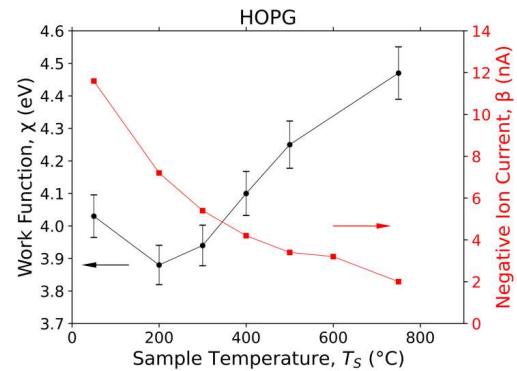


Figure 1: Work function and negative ion current of HOPG with respect to sample temperature

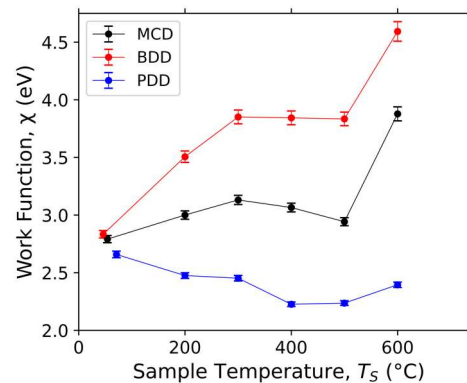


Figure 2: Work function variation with respect to sample temperature for doped diamond samples

References

- [1] G. Cartry et al. New Journal of Physics, 19(2), 2017. ISSN 13672630.
- [2] R. Magee et al. Plasma Sources Science and Technology, 32(7):75021, 2023. ISSN 13616595.