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Langmuir Probe Characterization of Hydrogen Plasma for the Production of Nano-crystalline Diamond

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Formation of nano-crystalline diamond layer on top of a Si substrate has been confirmed with scanning electron microscopy and X-ray diffraction with electron cyclotron resonance (ECR) excited hydrogen plasma. The system does not require additional supply of hydrocarbon gases, but a graphite target immersed in hydrogen plasma forms hydrocarbon flux onto the Si substrate. Thus, chemical sputtering process on the graphite target plays a key role in deposition rate, and quality of the formed nano-crystalline diamond layer. Figure 1 shows the shape of plasma glow observed by taking out the holder for the Si substrate. At the reduced pressure of several Pa, the shape of the plasma is determined by the magnetic field lines of force. When the pressure increases up to about 100 Pa, plasma rapidly diffuses out and the plasma glow becomes no more obvious on the surface of the graphite target.

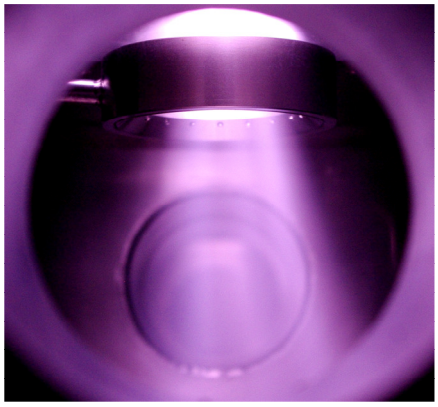

Fig. 1. Picture showing the plasma glow near the region of the graphite target. The Si substrate is located at the center, where the tip of the Langmuir probe has been positioned.

Langmuir probe measurements were performed to characterize ECR excited hydrogen plasma as a function of H_2 pressure at constant microwave power. Shorter mean free path at higher pressure should result reduced electron temperature. The enhanced diffusion at higher pressure will reduce the electron density, but more frequent collision can increase ionization event when the system delivers microwave power to the reaction region. The results shown in Fig. 2 clearly indicate the loss due to cross field diffusion is substantial, and the plasma is not transported to the target area effectively. The system is being modified so as to move the ECR point closer to the graphite target surface.

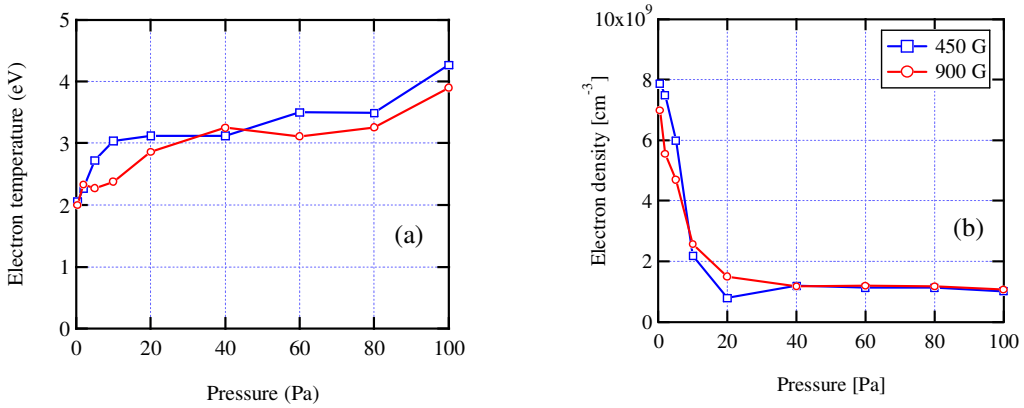

Fig. 2. Electron temperature (a) and density (b) of microwave (ECR condition) excited plasma for two different magnetic field intensities.