PHOTO ELECTRON EMISSION MICROSCOPY (PEEM), FIELD EMISSION ELECTRON MICROSCOPY (FEEM) AND THERMIONIC FEEM OF NITROGEN AND SULFUR DOPED CARBON FILMS.

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We have studied Nitrogen doped diamond films and Sulfur doped Carbon Films as low temperature thermionic-field electron sources. Nitrogen doped Diamond Films have been synthesized by Plasma Enhanced CVD on Si (100) and molybdenum substrates. Sulfur doped films have been prepared by HFCVD on molybdenum substrates. [1, 2] Raman Spectroscopy for the Nitrogen doped Films shows a peak at 1340cm^{-1} characteristic for diamond and a broadened peak at 1554cm^{-1} corresponding to sp^2 bonded carbon. Sulfur doped films show two broad peaks at 1354cm^{-1} and 1590cm^{-1} indicating nanocrystalline diamond. Photo Electron Emission Microscopy shows a uniform electron emission at room temperature for the nitrogen doped diamond films in contrast to a strongly localized electron emission for the sulfur doped films. Surface treatment of the nitrogen doped diamond films enhances electron emission at elevated temperatures starting at around 600ºC that increases with increasing temperature. Hydrogen and Titanium passivation induce a negative electron affinity to lower the energy barrier for electrons to escape into the vacuum. [3] The degradation of the Hydrogen layer starts at ~ 720ºC in contrast to the Titanium layer that is stable up to 950ºC. At elevated temperatures the electron emission for the nitrogen doped films as imaged with the Electron Emission Microscope shows a uniform distribution over a wide surface region. Sulfur doped carbon films with electron emission originating mainly from 'hot spots' on the surface at room temperature show an increase in electron emission from those localized regions at temperatures as low as 340ºC. Nitrogen introduces a single substitutional donor level at 1.6eV below the CBM, as well as the incorporation of other defect levels. [4, 5] These defect states may play an important role in enhancing electron emission especially at high fields. The energy levels induced by sulfur in diamond are calculated to be 0.15 and 0.5eV from the bottom of the conduction band, for S-0 and the singly ionized state S+, respectively. [6] The contribution of different states to the electron emission for the nitrogen and sulfur doped films has to be investigated.

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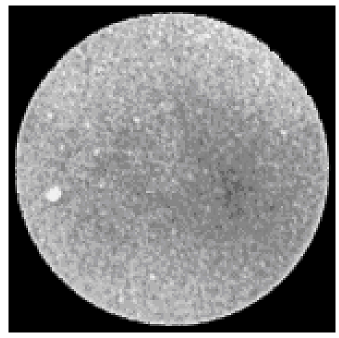
Figure 1 Thermionic FEEM of Nitrogen doped, H-passivated diamond at 725ºC.

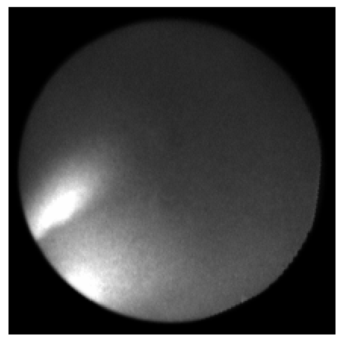
Figure 2 Thermionic FEEM of Sulfur doped nanocrystalline diamond at 340ºC.