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Micro Characterization of the Diffusion of Cr in Natural Diamond Particles

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The development of new technology based on diamond provides a promising future due to the ability of diamond to be adapted to several conditions such as radioactive environments and space exploration. Diamond is a wide band gap material with unique combinations of properties useful for a number of applications like harsh and chemically corrosive environments. Elemental doping of diamond may change the structure of the crystal along with the electronics and physical properties of diamond such as resistivity, strength and heat capacity. The recently proven ability to diffuse several elements in natural diamond that can act as donors or acceptors has opened the possibility of developing micro-electronic applications like sensors and LED's that can tolerate such extreme environments [1-2]. The diffusion method provides an alternate mechanism for the incorporation of impurities in diamond without creating extensive damage which results due to other techniques such as ion implantation [3]. The study of the diffusion process and its effect on diamond is then of vital importance for the development of novel materials in the next generation of micro and nano electronics, surface coatings, optical windows and biological and chemical sensors.

In this work experimental results for the diffusion of Chromium (II) in natural diamond powder (Cr-DDP) of 60-70 micron size are presented. SEM micrograph and elemental analysis was performed in the Electron Microscopy Core Facility at the University of Missouri-Columbia. Secondary electron (SE) images (Fig. 1A, B) show an increase in surface roughness, rounding of crystalline facies by oxidation and micro fractures in the treated diamond. Backscattered electron (BSE) images revealed deposition of Cr (bright areas) on the surfaces of diamonds after doping, see Figures 1C and 1D. Energy-dispersive spectroscopy (EDS) in figure 2A confirmed that the bright areas (fig. 2B) in a polished cross-section contained Cr on the perimeters along with oxygen from the cleaning process and Si from the quartz container. A closer look (fig. 2C) of the interior of the diamond reveals Cr deposition location ~100 – 200 nm in diameter. Raman analysis on the Cr-DDP shows an increase in disorder in the sample. Some weak, broad bands were also observed possibly due to the Cr doping and amorphization of the diamond structure. This work presents strong evidence that Cr can be diffused into natural diamond and demonstrates that our diffusion process is a powerful technique for the diffusion of new impurities in wide band-gap material.

References

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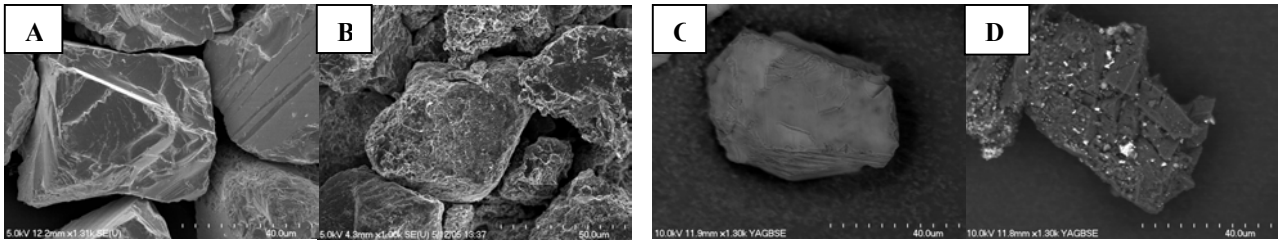

Fig 1. Micrographs of an untreated sample (A, C) and Cr-treated sample (B, D) showing morphological changes and Cr deposition.

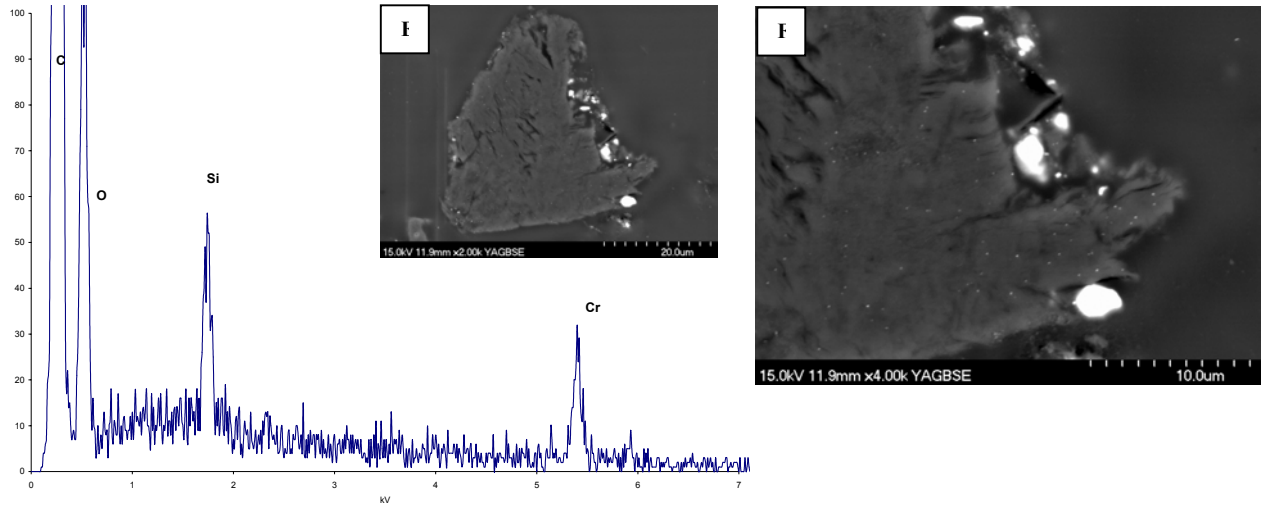

Fig. 2. Energy-dispersive x-ray spectra of the Cr-DDP specimen. Electron Beam accelerating voltage = 15 kV, x-ray counting live time = 100 sec. E-F. SEM / BSE mode micrograph of a cross section of a treated sample. Brighter areas were identified as areas of high Cr concentration.

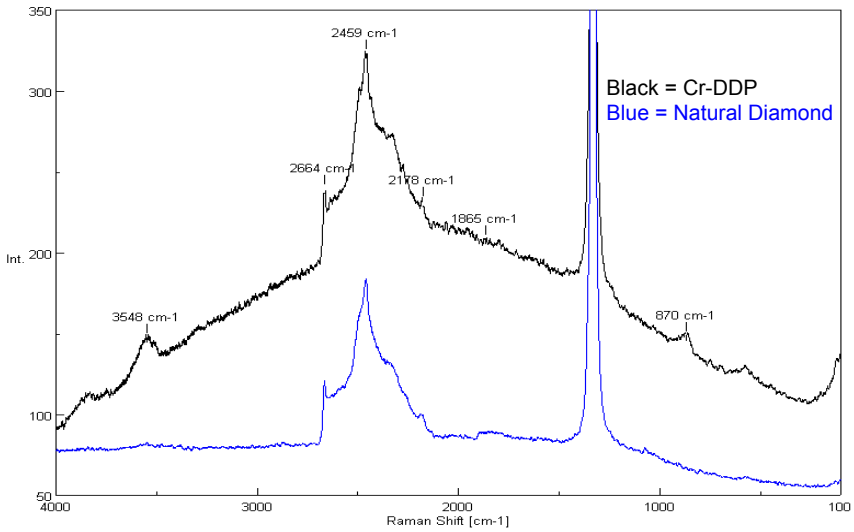

Fig. 5. Raman analysis of the Cr-DDP. The sample exhibits one main Raman active vibration which manifests itself as a sharp first order peak in the Raman spectrum at 1331 cm-1. Some weak, broad bands (3,548cm-1, 870cm-1) are possibly emission (photoluminescence or fluorescence) due to the Cr doping.

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