Manufacturing/Synthesis and Nanostructure of Superhard Thin Films/Materials

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Highlight:

The primary objective of this project is to develop manufacturing processes for synthesizing novel superhard materials of controlled nanoscale-structures and properties in the focussed composition region of the ternary (C-B-N) system. This is achieved by developing manufacturing processes for synthesizing novel thin films by ECR (Electron Cyclotron Resonance)-Microwave Plasma Enhanced CVD (ECR-MPECVD), and characterization of their structure/nanostructure to relate to unusual properties.

Two areas were emphasized during this year. One was aimed at developing in-situ capabilities for monitoring deposition conditions, and second was related to synthesis and characterization of nanocrystalline diamond thin films at low temperatures of <300°C. Towards the first objective, we installed a QMS (Qudrapole Mass Spectrometer) to monitor chemical species that are produced in the plasma environment during deposition of nanocrystalline diamond. Another in-situ optical diagnostic tool (an optical spectrometer) that can obtain spectral information from the plasma was also installed on the ECR-MPECVD system to identify the chemical species based on their spectral response. The QMS and optical spectrophotometer are interfaced with a PC to continuously obtain and record real time data from plasma environment during deposition.

Towards second objective, the nanocrystalline diamond thin films were successfully deposited on Si and SiC single crystal wafers at a low temperature of ~275-300°C (see Fig. 1). Diamond coating thickness ranging from 2.6 to 5.7 micrometers was obtained. X-ray diffraction and Raman spectroscopy data clearly indicated that well-formed crystalline diamond thin films can be deposited at low temperatures of 275°C. Future work is planned to further characterize these films and synthesize superhard materials in the C-B-N system. Properties (thermal conductivity, hardness, electrical, and optical) of the diamond and C-B-N films will also be measured and related to the processing conditions.

Relevance:

The successful low temperature synthesis of diamond films has important implications on use of diamond films for microelectronic devices and packaging because of the high thermal conductivity. In addition, unusual properties such as hardness will find applications of thin films as coatings on machining tools.

References

[1] For further information about this project contact PI at Raj.Singh@uc.edu