Synthesis of cBN by Direct Current Arc Discharge Method

J. Zhang¹, Q. Cui¹, X. Li¹, Z. He¹, W. Li¹, Y. Ma¹, Q. Guan², G. Zou¹

¹National Laboratory of Superhard Materials, Jilin University, 130012, P. R. China
²Institute of Materials Science and Engineering, Jilin University, 130025, P. R. China

Cubic boron nitride (cBN) has a unique combination of a number of highly desirable mechanical, chemical, thermal, electrical and optical properties [1,2]. In particular, it is superior to diamond in that it does not react with ferrous metals readily. Furthermore, because cBN is a wide bandgap ($E_g \approx 6$ eV) semiconductor with a good thermal conductivity, it has the potential usage in high temperature and high power electronic applications. Thus the deposition of cBN thin films as well as the synthesis of bulk cBN materials has attracted extensive worldwide efforts.

In this paper, we will report the synthesis of cBN nanocrystals by the direct current arc discharge method with hBN and NH₃ as the starting material and the working gas, respectively. By this method, we have fabricated nano-scaled cBN crystals under high temperature (3000K) and low pressure (10 kPa) conditions. We suggest that the growth of cBN undertakes a sublimation–re-hybridization–crystallization route. The sublimation of (BN)$_x$ segments is caused by the high temperature and the bombardment of high energy particles. Then the segments transform from sp²-hybridized to sp³-hybridized bonding on adsorptions of H, NH, NH₂ or NH₃ radicles. At last, during the fast refrigeration process the crystallization of cBN occurs. The kinetic barrier hindrance is thus overcome by the cooperation of extremely high temperature and bombardment of high-energy particles.