Solution Growth and Properties of Monoisotopic Hexagonal Boron Nitride Single Crystals

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High quality hexagonal boron nitride (hBN) crystals with a single boron isotope (ie monoisotopic) were produced at atmospheric pressure using a molten metal flux [1]. Metal solvents successfully tested for hBN crystal growth included nickel plus chromium, and iron plus chromium [2]. Crystal growth was achieved by dissolving the boron and nitrogen (from N_2, naturally 99.6% ^{14}N) source materials in the solvent at 1550 °C, then slowly cooling (<4 °C/h) to reduce the solubility, causing hBN to precipitate. The typical size of these randomly nucleated hBN crystals is on the order of 500μm to 2 mm across, and tens of microns thick, Figure 1. In this study, pure boron powders that were a single isotope (>99% isotopic purity) were employed as the boron sources. This is in contrast to natural boron, which consists of two stable isotopes, ^{10}B (79.9 at%) and ^{11}B (20.1 at%). With only one isotope, isotopic disorder, the random distribution of boron isotopes, is eliminated, leading to a change in the hBN's properties. Most dramatically, phonon lifetime is increased. Consequently, the 300 K in-plane thermal conductivity is increased from 408 $W \cdot m^{-1} \cdot K^{-1}$ for $h^{nat}BN$ to 585 $W \cdot m^{-1} \cdot K^{-1}$ for $h^{10}BN$ [3]. The reduced infrared optical losses in monoisotopic hBN is advantageous for nanophotonic devices based on hyperbolic phonon polaritons. Its use leads to stronger light-matter interactions and nonlinear effects. The challenges to growing larger hBN crystals will also be addressed.

References

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Figures

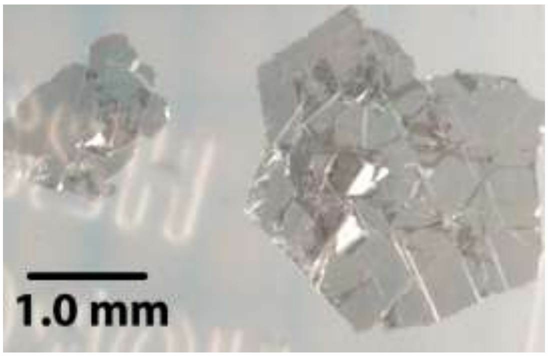

Figure 1: Optical photograph of B-10 enriched hBN crystal flakes.