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PLASMAS FOR ULTRAWIDE BANDGAP MATERIALS

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Ultrawide bandgap materials such as diamond and hexagonal boron nitride (hBN) are a class of semiconductors with bandgaps in excess of ~5 eV that are desired for high-power, extreme environment, and ultraviolet applications. While these materials have been been studied for many decades now, new properties continue to be unearthed because of synthetic challenges and advances in measurement tools.

In this talk, I will present two efforts, one related to diamond and the other related to hBN. First, we have recently discovered intervalence band plasmons in boron-doped diamond, defined as collective electronic excitations between the valence subbands.[1] To probe these low-energy (<0.5 eV) transitions, we applied several relatively advanced techniques, including scanning transmission electron microscopy-valence electron energy loss spectroscopy (STEM-VEELS) and scanning near-field optical microscopy (SNOM), and carried out first-principle calculations. While plasmonic behavior in doped semiconductors is well-documented, it has typically been attributed to Drude excitation of free charge carriers (e.g., holes). Our study shows the possibility of other mechanisms for the measured plasmonic response. Second, we have developed an understanding of infrared spectroscopic characterization of hBN which can be applied directly on copper or other metallic substrates that are common growth substrates, unlike Raman spectroscopy.[2] Insight can be obtained into the growth process by analyzing different peaks without the need to transfer, accelerating optimization. Finally, we demonstrate that the addition of a plasma can lower the growth temperature and allow direct growth of hBN on alternative substrates such as silicon and stainless steel.

References

1. S. Bhattacharya et al., *Nat. Comm.* **16**, 444 (2025).
2. In preparation.