Dielectric permittivity and strength of hexagonal boron nitride

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Hexagonal boron nitride (hBN) is a van der Waals insulator extensively used as gate dielectric in 2D material heterostructures. It is important to improve its characterization in terms of low-field permittivity and high-field strength up to the breakdown voltage. The present study, based on DC and RF transport in Au-hBN-Au capacitors aims at filling this gap. We benchmark two capacitor series: one with high-pressure, high-temperature crystals (NIMS) and one with crystals obtained by the polymeric route (LMI).

From RF measurements in hBN crystals of thickness 10-100 µm, we extract a recommended value for the dielectric constant $\epsilon = 3.4 \mp 0.2$, which narrows down the commonly used estimate $\epsilon = [3 \rightarrow 4]$.

Dielectric strength is characterized by monitoring the leakage current as function of DC bias. It is well described in terms of a non-linear dielectric conductivity with turns out to obey the Frenkel-Pool trap-assisted, thermally activated, Schottky transport law [1,2]

$$\frac{J}{E} = \sigma_{BD} \times Exp\left[-e\frac{\Phi_B - \sqrt{eE/\pi\epsilon_0\epsilon}}{kT}\right] \qquad (1)$$

where Φ_B is the deep-level trap energy and σ_{BD} the conductivity for fully ionized traps. Figure 1 illustrates the characteristic $\sqrt{E}$ lowering of the trapping barrier, and the thermally activated nature of conductivity (inset). We find a small variability of the trap energy, $\Phi_B = 1.27 \mp 0.03\, eV$ for the best samples and $\Phi_B \leq 1\, eV$ for defective samples. The largest value is quite comparable with literature measurements in SiO2 [3] and Si3N4 [4].

References

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Figures

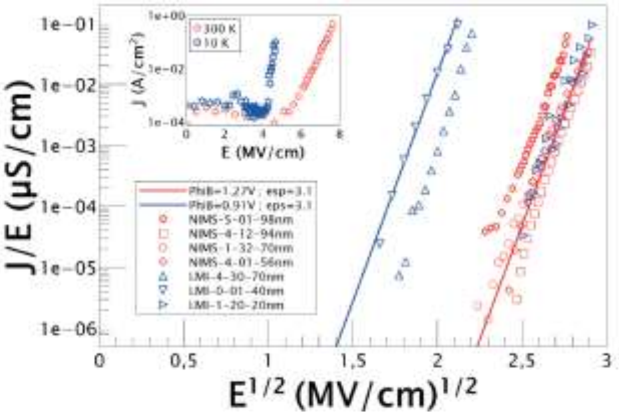

Figure 1: Frenkel-Pool plot of high-field hBN conductivity. Red symbols correspond to NIMMS crystals and blue symbols to LMI crystals. Solid lines correspond to theoretical fits to the Frenkel-Pool law (1) taking $\sigma_{BD} = 0.1\, \mu S/cm$, $\Phi_B = 1.27\, eV$ (red line) and $\Phi_B = 0.9\, eV$ (blue line).