Resistive Switching and Current Conduction Mechanisms in Hexagonal Boron Nitride Threshold Memristors with Nickel Electrodes

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Hexagonal boron nitride (h-BN) has recently gained popularity as a material for resistive switching (RS) due to its desirable properties such as high thermal conductivity, stability, flexibility, and wide bandgap [1,2]. Furthermore, its van der Waals (vdW) structure enables integration on arbitrary substrates at low temperature. h-BN has shown both volatile and non-volatile RS [2] and its crystalline vdW layers promise controlled device operation. Mostly, metal filament formation is the suggested RS mechanism [3], supported by methods like conductive atomic force microscopy (C-AFM) [4] and transmission electron microscopy (TEM) [5]. However, both methods have their limitations when aiming for a non-destructive characterization of a practical device stack. Temperature-dependent electrical measurements are a non-destructive method to extract information about the RS mechanism representative of the entire device.
Here, we investigate the switching mechanism of Ni/h-BN/Ni cross point devices by performing an extensive study of the current conduction mechanisms in the different resistance states by performing temperature dependent electrical measurements (see Fig. 1) [6]. On this basis, we propose Ni-filament formation and spontaneous self-rupture across the h-BN film resulting in a volatile RS mechanism. The presence of Ni diffusion through h-BN is further confirmed by transmission electron microscopy. Thus, we demonstrate that temperature-dependent current-voltage analysis is a valuable tool for the investigation of resistive switching phenomena in 2D-material based memristors. The devices in this study exhibit volatile RS in a wide and tunable current operation range with low stand-by currents (~ 0.13 pA), low cycle-to-cycle variability of 5%, and a large resistance On/Off ratio of 10^7.

References

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Figures

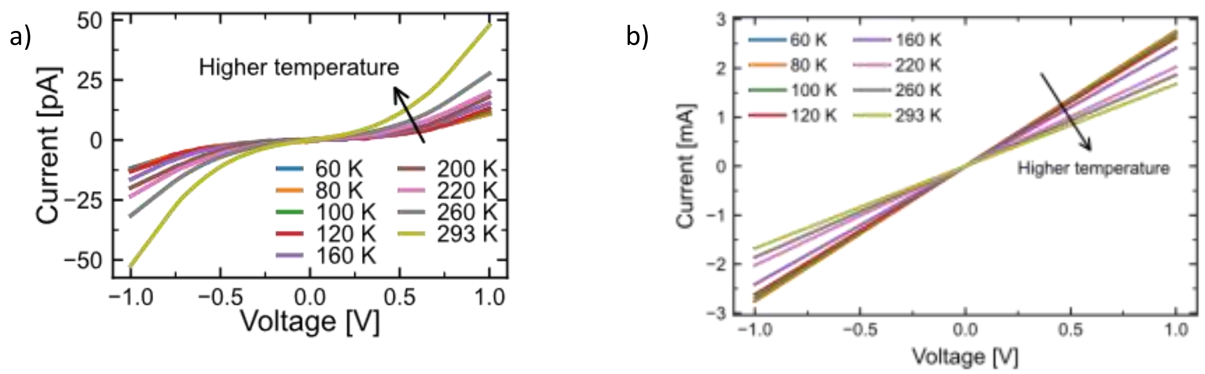

Figure 1: Temperature-dependent current-voltage curves of a h-BN memristor in its a) high resistance state and b) low resistance state.