Effect of Vacuum on the Forming Behaviour of h-BN based Memristors

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Recently, two-dimensional (2D) materials gained much attention as the resistive switching (RS) medium in memristor devices [1]. The insulating 2D material hexagonal boron nitride (h-BN) is of special interest, as it is an atomically thin insulator with a band gap of ~6 eV, promising good device performance like low off currents and a large switching window [2]. The predominant RS mechanism is believed to be metallic filament formation under voltage stress [3], analogous to electrochemical metallization (ECM) cells observed in the more mature metal oxide memristor family [4]. Ambient air molecules like water can significantly influence the RS behavior of metal oxide-based ECM cells [4]. Here, we thoroughly study the effect of vacuum, i.e. the absence of air molecules, on the forming of h-BN memristors.
We investigate the effect of vacuum on the RS of Palladium (Pd)/h-BN/Nickel (Ni) memristors (schematic in Fig. 1a) by comparing their response to voltage stress in ambient and vacuum conditions. Figs. 1b and 1c present forming attempts (current-voltage sweeps) of 16 and 8 devices in ambience and vacuum conditions, respectively. The switching parameters (forming voltage and current) that lead to the successful forming of the devices in ambient air are highlighted within grey regions. In contrast, no initial filament was formed under the same electrical stress in a vacuum, even after multiple attempts. We could strengthen our experimental findings with simulations of the SET kinetics of our devices in ambient and vacuum conditions using an established metal-oxide memristor model [5]. Our study extends the use of this model and has important implications for potential applications of h-BN memristors, as computer chips in end-use applications are usually encapsulated to protect them from atmospheric influences.

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Figures

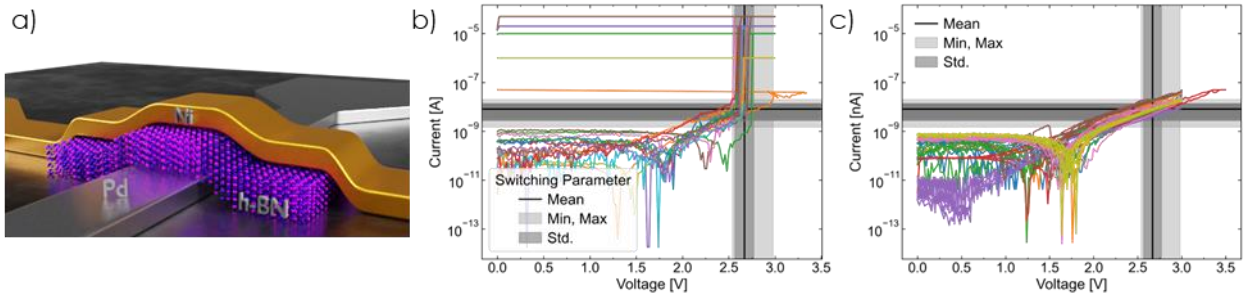

Figure 1: a) Device schematics. b) Forming of h-BN memristors in ambient conditions. c) Forming trials of h-BN memristors in vacuum conditions.