Low pull-in operation and high switching endurance observed for a graphene-hBN van der Waals contact NEMS switch

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Graphene is promising candidate for future nanoelectromechanical switch (NEMS) device applications as its ultra-thin of an atomic sheet, high Young's modulus, electrical conductivity, and mobility which leading to fast switching response, high on/off ratio and low actuation voltage [1-4]. Despite these potential advantages, the common failure of graphene-based NEMS (GrNEMS) is that graphene stuck on the electrode and not reversible after several retracting actuation voltages, which is simply ascribed to an irreversible static friction due to the formation of C-Au molecular covalent bond [5,6]. This is limiting them in the realization for multiple switching cycles and practical device application. In this work, the irreversible static friction has been overcome by realization weak Van der Waals bonds of graphene-hBN contact instead of a strong C-Au covalent bond. GrNEMS devices based on Van der Waals bonds of graphene-hBN were successfully fabricated by using chemical vapor deposition growth of graphene and single layer hexagonal boron nitride (hBN). The device shows instantly pull-in and pull-out at low voltage, less than 2 V pull-in and more than 1 V pull-out voltage, with current modulation between ON and OFF states of ~5 order. Switching performance was performed at pull-in voltage of 1.5 V, the device shows clear pull-in–pull-out with a high endurance of over 25000 switching cycles while maintaining an on/off ratio higher than 10^4. This result has great potential for future high-performance NEMS devices in memory storage, high-frequency communication, and logic circuit applications.

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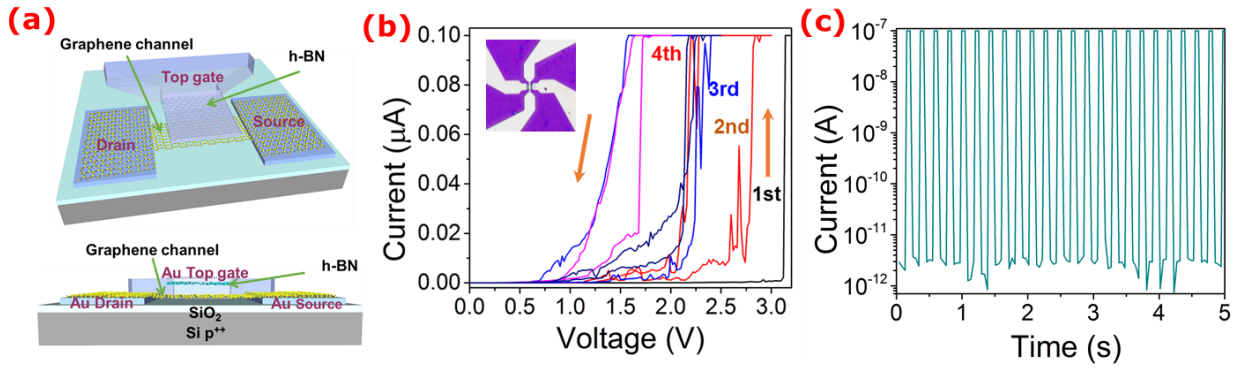

Fig. 1 (a) Graphene NEMS device structure, (b) switching characteristics, and (c) switching performance at pull-in voltage of 1.5 V with a double-clamped beam graphene switch of L = 1 μm ; W = 500 nm.