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Field emission induced lower switching power of TiO2 memristor using CNT-array as bottom electrode
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Memristors are the most promising candidate for next generation of memory devices and also for mimicking the synapses of the human brain [1]. The mostly accepted switching mechanism for oxide-based memristors is rely on formation/rupture of conductive filaments of oxygen vacancies and also changing the Schottky-barrier height at the interface of layers by applying a suitable bias voltage [2]. Therefore, controlling the electric field distribution in an active layer (i.e. TiO2) is a fundamental requirement for optimizing the performance of a memristor device [3].
In this research, we have used an array of carbon nanotubes (CNT) as bottom electrode (BE) of TiO2 based memristor device to apply its local field effect for reducing the working voltage. To grow the layer of CNT's arrays, we have employed plasma enhanced chemical vapor deposition (PECVD) by using a pre-patterned Ni thin film as a catalyst through applying sputter deposition and photolithography patterning in a 50 μm line width. In the next step, we have used both radio frequency (RF) sputtering and CVD methods (for comparison) to deposit TiO2 thin film as the active layer with an optimized thickness of about 60 nm. In the final step, DC sputtering technique was utilized to deposit Au thin film as top electrode (TE) and finally it patterned with a line width of 30 μm. Surface morphology of the device was analyzed by scanning electron microscopy (SEM) and its electrical property was investigated by I-V measurements. Moreover, we investigated the field emission of CNT array as an excellent emitter.
Based on our data analysis, it was found that the surface morphology and nanostructure of the TiO2 film deposited by CVD is more uniform and compact as compared to TiO2 film prepared by sputtering method. Thus, we have patterned Au thin film with a crossbar structure on top of the CVD deposited TiO2 thin film. In addition, I-V measurements also showed a low required working voltage of 0.89 V for the prepared CNT array as bottom electrode of the device that leads to a lower required switching power from high to low resistance state. The reduction in switching power is due to enhance local electric field intensity of the field emission generated from the surface of the CNT array at the BE/active layer interface.

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