Roll-to-Roll Gravure-Printed Flexible Neuromorphic Devices Based on Carbon Nanotubes and $BaTiO_3$ Nanoparticles

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Neuromorphic semiconductors inspired by the human brain offer a new paradigm beyond the limitations of conventional CMOS-based electronics. In this study, we propose a flexible neuromorphic semiconductor device fabricated on a plastic substrate using a roll-to-roll gravure printing process. The device utilizes interface trap-assisted mechanisms induced by the ferroelectric polarization of $BaTiO_3$ nanoparticles, together with the channel properties and charge-trapping behavior of carbon nanotubes, to realize nonvolatile memory operation and tunable synaptic functionalities. The fabricated device exhibits an ON/OFF ratio exceeding and demonstrates a memory window of approximately 50%. Furthermore, it maintains consistent electrical characteristics without any noticeable degradation, even after more than 300 repeated measurement cycles. The robust operational stability of the device was comprehensively confirmed through its excellent endurance of over 1,000 cycles and a prolonged data retention performance exceeding 30,000 seconds. Statistical analysis of a 10x10 device array revealed excellent spatial uniformity with narrowly distributed On current and Off current. In addition, the device maintains stable electrical and memory characteristics under mechanical deformation, showing no degradation in stored data after bending. Even after more than 10^5 bending cycles, the device retains its performance, demonstrating excellent mechanical reliability and suitability for flexible neuromorphic electronics.

[1] H. Park et al., Advanced electronic materials, 6 (12), 2000770, 2020.

[2] J. Gao et al., Advanced functional materials, 32 (17), 2110415, 2022.