

Neuromorphic computing based on a graphene-gold nanoparticle hybrid floating-gate memristor

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Abstract

As data-intensive AI tasks increasingly challenge the energy efficiency of traditional von Neumann architectures, neuromorphic computing has emerged as a promising alternative for realizing low-power, hardware-intrinsic intelligence. Among various synaptic candidates, floating-gate memories (FGMs) are highly regarded for their reliability and high-resolution multi-level operation, which are essential for stable synaptic weight modulation. However, the high operating voltages (typically >10 V) required for charge tunneling in conventional FGMs remain a significant barrier to energy-efficient scaling.

In this work, we report a graphene/gold nanoparticle (G/NP) hybrid floating-gate memristor (FGMEM) designed to overcome these voltage limitations. By integrating Au-NPs on monolayer graphene, we utilize localized electric field enhancement—or "hotspots"—to facilitate efficient Fowler-Nordheim tunneling at operating voltages as low as 3 V. This architecture achieves a robust ON/OFF ratio exceeding 10^4 while maintaining the high tunability required for synaptic functions.

To demonstrate its practical utility, we implemented a hardware-based neuromorphic system comprising 120 synapses and 8 neurons. Using a differential weighting scheme, the system successfully performed real-time supervised learning and classification of alphanumeric characters ('A', 'B', 'Y', and 'Z') with enhanced sensing margins. These results suggest that G/NP-FGMEMs provide a viable pathway for developing scalable, low-power neuromorphic hardware.

References

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Figures

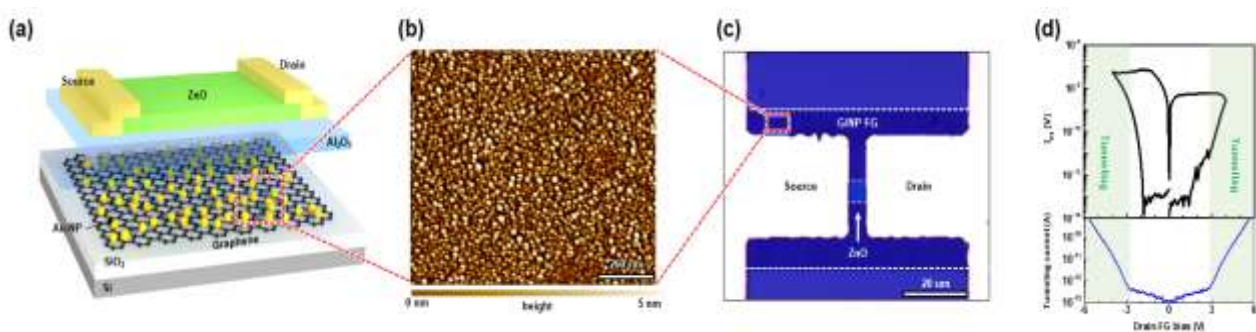


Figure 1: (a) Schematic illustration of the graphene-gold nanoparticle(G/NP) floating-gate memory (FGMEM). (b) AFM height image showing the Au-NPs on the monolayer graphene surface.(c) Top-view optical microscope image of the fabricated G/NP-FGMEM device; scale bar, 20 μ m. (d) Transfer curve (I_{dS} - V_{dS} hysteresis) and tunneling current of G/NP FGMEM.