Direct synthesis and CMOS integration of 2D materials towards logic and memory devices

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Two-dimensional (2D) materials are of great interest for advanced complementary metal-oxide-semiconductor (CMOS) electronics as well as for beyond-CMOS including neuromorphic and in-memory computing technologies. Hexagonal boron nitride (h-BN), a 2D layered insulator, has attracted much attention for non-volatile resistive-switching (NVRS) devices (i.e., memristors) due to outstanding electronic, mechanical, and chemical stability. However, the integration of h-BN memristors with Si-CMOS electronics is crucial to achieve practical technologies, and existing methods are incompatible with Si integration and manufacturing at the wafer-level. In this talk I will briefly present our recent efforts towards direct synthesis of h-BN films, enabling transfer-free CMOS-compatible memristors with outstanding electrical characteristics. We have demonstrated wafer-scale integration of h-BN memristors with >90% yield, high stability in NVRS characteristics, high conductance programming precision for multistate operation, and remarkable low-frequency noise performance with negligible random telegraph noise (RTN) characteristics. Furthermore, we directly integrate memristive devices on industrial Si-CMOS testing vehicles to demonstrate excellent endurance achieving millions of programming cycles with a high technology readiness level.