Introducing layered dielectrics in solid-state microelectronic devices

Abstract

The introduction of two-dimensional (2D) layered materials in the structure of microelectronic devices is a promising strategy to enhance and extend their performance. Several 2D layered metallic and semiconducting materials (e.g. graphene and MoS_2) have been successfully implemented in different types of devices. However, their interaction with traditional dielectrics (e.g. SiO_2, HfO_2, Al_2O_3) is very poor because 2D materials do not have dangling bonds, leading to a highly defective interface. To solve this problem, the most feasible solution is to couple graphene and MoS_2 with 2D layered dielectrics, so that they can form a clean van der Waals interface. In this context, h-BN is a 2D layered dielectric (with a direct band gap of ~5.9 eV) in which boron and nitrogen atoms arrange in a sp^2 hexagonal lattice by covalent bonding, whereas the layers stick to each other by van der Waals attraction. Given its high in-plane mechanical strength (500 N/m), large thermal conductivity (600 $Wm^{-1}K^{-1}$), and high chemical stability (up to 1500 ºC in air), h-BN has attracted much attention as dielectric. In this seminar, I will present our studies on the use h-BN as dielectric in microclectronic devices, and our most recent progress on the wafer-scale integration of memristive crossbar arrays made of 2D layered materials. By using chemical vapor deposited multilayer hexagonal boron nitride (h-BN) sheets, we have fabricated metal/h-BN/metal memristive crossbar arrays that exhibit, not only outstanding electrical characteristics, but also a high yield and low device-to-device variability. These findings may accelerate the use of 2D materials for building wafer-scale and high-density electronic memories and artificial neural networks.