

## h-BN tunnel barriers with atomic-level thickness controls for versatile integrations

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A tunnel barrier with a precisely controlling thickness is a key element for tunnel devices. Atomically thin hexagonal boron nitride is an ideal tunnel barrier to precisely control tunneling current and versatile integrations with different materials. However, the fabrication of h-BN films with spatial uniformity is challenging. Here, we fabricated the uniform and large-scale h-BN tunnel barriers using layer-by-layer assembly of monolayer hexagonal boron nitride with controlling the thickness at the atomic scale and keeping interfacial cleanness. The clean interfaces and thickness controllability are identified by scanning transmission electron microscopy (STEM). The resistance of batch-fabricated vertical device (Au/h-BN/Au) arrays is exponentially dependent on the number of h-BN films.