Ultrathin Indium-Gallium Oxide Nanosheets based on a Low-Temperature Printing Process

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Faced with the down-scaling of semiconductor devices and the rapid development of 2D materials for high-performance field-effect transistors,[1] ultrathin oxide nanosheets with high dielectric constant are of interest as gate dielectrics.[2] Here, we report on the synthesis and properties of ultrathin Indium-Gallium oxide (InGaO) nanosheets fabricated using a simple liquid-printing process.

Indium-Gallium alloy droplet is preheated on substrate at a certain temperature, therefore, In-Ga alloy undergo self-limiting Cabrera–Mott oxidation process and InGaO nanosheet forms on top of liquid metal alloy in ambient air, and then thin InGaO layer is squeezed by another piece of preheated substrate.[3] The remaining metal inclusions are removed by facile mechanical washing process using boiling ethanol. The substrate temperature was varied over the range form 115℃ to 300℃ to assess its effect on the growth and properties of the InGaO nanosheets.

The thickness and morphology of the films was studied using atomic force microscope (AFM), while their composition was determined using by X-ray photoelectron spectroscopy (XPS) and Rutherford backscattering spectrometry (RBS). This was complemented by analysis of their crystal structure using Raman spectroscopy and X-ray diffraction. The electrical conductivity of the films was studied using conductive atomic force microscope (CAFM), and simple metal-oxide-semiconductor capacitors were used to measure their dielectric constant and breakdown electric field. By measuring the capacitance and doing calculation, the maximum dielectric constant of ~3nm thick InGaO nanosheet which was synthesized at 115℃ was found to be ~7. Other results from these studies are reported with reference to the properties of bulk indium and gallium oxides.

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