2D Bismuth for Flexible Thermoelectric and Photoelectric Electronics

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Abstract

Bismuth(Bi) is a post transition metal with a high carrier mobility ~20 000 cm2 V^{-1} s^{-1}[1] and low thermal conductivity ~10 W m^{-1} K^{-1}[2]. Bismuthene, 2D Bi, is similar to black phosphorus with tunable bandgap[3, 4] and expected isotropic properties. It is of great interests and importance to exploit its potential in thermoelectric devices, photodetectors, transistors and other nanoelectronics.
Although there have been studies on 2D Bi and its transistor devices[5], thermoelectric and photodetectors on hard substrates[6], there is a lack of experimental demonstration on the large-area uniform 2D Bi and its devices especially on flexible substrates[7]. Herein, we prepared 2D Bi with precise thickness control on Si and flexible polyimide substrates by physical vapor deposition, and integrated solid-state devices to probe thermoelectric and photoelectric response. 2D bismuth exhibited superior mechanical flexibility, and descent electrical properties that can be controlled via thickness and interface engineering. E-beam evaporated 2D bismuth could yield Seebeck coefficient and electrical conductivity comparable to molecular epitaxy counterparts, and an 50% enhanced performance on polyimide than Si. Our results suggest 2D bismuth with photoelectric and thermoelectric effects holds great promise for flexible multifunctional devices.

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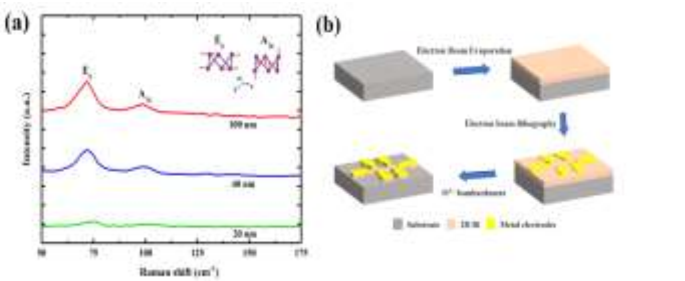

Figure 1: Raman spectra of 2d Bi in different thicknesses. (a) A_{1g} and E_g characteristic peaks corresponding to two vibration modes. (b) FET fabrication with lithography, deposition and etching processes.

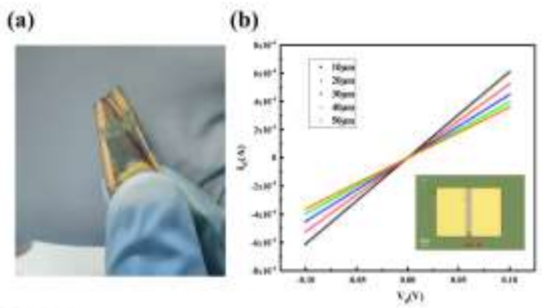

Figure 2: Field effect transistors of 2D Bi on polyimide. (a) Mechanical flexibility and light transmittance of the device. (b) I_d-V_d curve with different channel widths.