Photoelectric Effects of Bismuthene for Innovative Sensing and Energy Devices

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Bismuthene, two-dimensional (2D) buckled Bi atomic sheet, is expected to have tunable bandgap (~0.3 eV)[1] in between graphene and transitional metal dichalcogenides[2,3], holding great promise for exotic electronic properties. Even though the synthesis of Bi thin film has made great progress[4,5], there is still a lack of experimental device integration and characterization study. Here, while exploring its field-effect device behavior, we discovered unique photoelectric effect of bismuthene not yet been reported.

Centimeter size uniform bismuthene (Fig.1) samples were grown on Si(111) via our previously developed molecular beam epitaxy method[5], followed by a universal Xene device integration process[6] to fabricate transistor devices (Fig.2) suitable for photoelectric measurements. Noteworthy, it needs a careful design of each layer and interface for device fabrication on 2D Xenes like phosphorene, silicene and bismuthene to avoid degradation. Our preliminary results (Fig.3) recorded more than one magnitude increase in drain current for 3ML (~1 nm) bismuthene under visible to IR laser exposure. Such strong photocurrent is indeed from Bi layer rather than bare Si(111) substrate. This observation implies that bismuthene could not only enable highly-sensitive photo detection devices, but also been tuned by photons as additional gate modulation knob compared to DC voltage or strain or chemical approach to tailor electronic performance. The response time of photocurrent effect on our bismuthene device is ~41ms comparable to most frequently used bulky counterparts. Further study is on-going to depict the effect of light frequency and intensity to photo response of bismuthene. Our work explored material and device performance of bismuthene, which would pave a way to innovative sensing and energy device applications for 2D Xene materials.

Reference:
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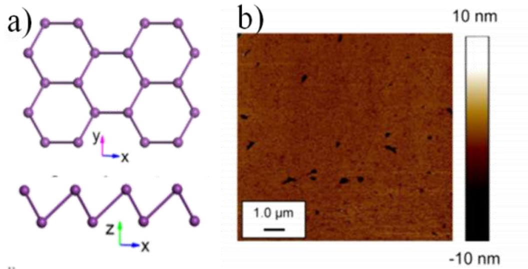

Figure 1: Bismuthene. (a) top and side view of atomic structure and (b) AFM image of a typical surface morphology.

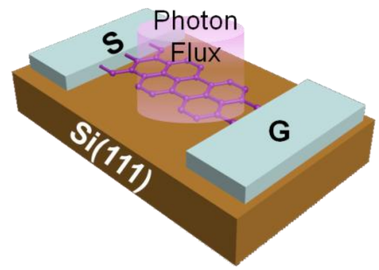

Figure 2: Schematics of a bismuthene device for photoelectric measurement.

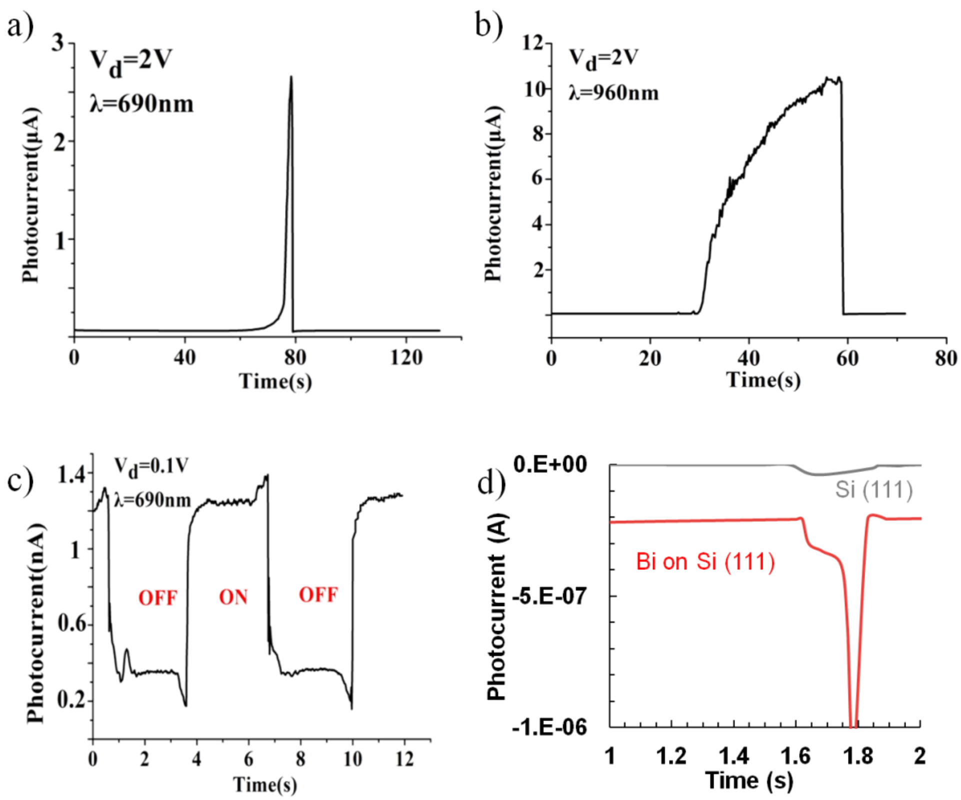

Figure 3: Photoelectric Response of bismuthene. The photocurrent excited by **a**) visible 690 nm and **b**) IR 960 nm lasers with excitation current changes continuously. **c)** The photo response to 690 nm laser with constant radiation. **d)** Control experiments showing strong photocurrent from bismuthene layer instead of Si(111) substrate.