Tellurene – A New 2D Group VI Tellurium Allotrope

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Numerous 2D materials such as graphene, silicene, phospherene, and various transition metal dichalcogenides (TMDs), have been explored in a great deal due to their novel structure and tunable properties. In contrast, group VI elements such as tellurium or selenium have yet to be stabilized in purely 2D forms, which may be due to its stable covalently bonded Te atomic chains that spiral along its c-axes. In this case, a typical exfoliation technique to produce 2D monolayers would not work. Here, we report the first experimental realization of a 2D group VI tellurium chalcogen, namely tellurene. Ultra-thin flakes of tellurium with controlled thickness were produced by substrate-free solution process. Each 2D tellurene flakes have thicknesses ranging from 15 to 100 nm. Tellurene flakes with a thickness smaller than 10 nm were also produced through a solvent-assisted post-growth thinning process [1]. A single atomic layer 2D tellurium was also synthesized by a wafer-bonding assisted self-assembly process, a new approach to synthesize and stabilize the low-dimensional structure [2]. Each monolayer Te atom has four nearest neighbors within the plane with inter-atomic distances of 0.31 – 0.32 nm, as shown in figure 1. First-principles calculations found tellurene to be metallic, with electronic band structures containing Dirac-cone-like features and exhibiting significant asymmetric spin-orbit band splitting. These findings enable further research into the suitability of tellurene for device applications, such as spintronics and quantum computing [3].

References

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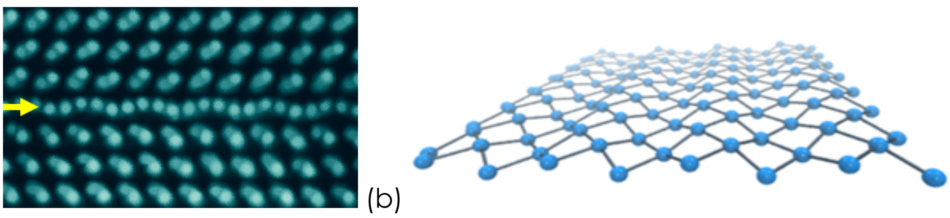
Figures

(a)



(b)

Figure 1: (a) Atomic resolution scanning transmission electron microscopy (STEM) high angle annular dark field (HAADF) image of the monolayer tellurene (as indicated by the yellow arrow) stabilized in between the CdTe layers by wafer bonding (Psuedo-colored for easy viewing). (b) Perspective view (above the z-axis) of the tellurene layer.