Growth of ultrathin tellurium films on gold and dielectric substrates

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Two-dimensional (2D) monoelemental materials are on the rise due to their unprecedent physical properties such as thickness-dependent electronic band structures, and tunable optoelectronic properties [1,2]. In this contest, the 2D form of Tellurium (Tellurene) is emerging as an appealing material for various technological applications [3]. Indeed, tellurium is composed of covalently bonded atoms arranged in hexagonal chains connected by van der Waals forces that exhibit highly anisotropic properties that can be utilized in many applications requiring anisotropic behavior [4].

In this work we will pay attention to establishing the growth methodologies to obtain ultra-thin tellurium films, down to the monolayer limit, at large-scale (≈ cm^2) on two different technological platforms, namely conductive substrates such as gold (Au) and dielectric SiO_2 on Si (p^+) substrates. In both cases, the deposition conditions of the growth are guided by simulations, which theoretically reproduce the experimental details within finite element methodologies. The structural, chemical, and morphological properties of the materials are investigated in detail by means of micro-Raman spectroscopy, X-ray photoelectron spectroscopy and atomic force microscopy (AFM).

On the one hand, taking advantage of the conductive Au substrate, we investigated the electrical properties of the ultrathin tellurium films at the local scale using conductive AFM therein revealing a resistive switching behavior at relatively low set voltages. On the other hand, to gain a deeper insight into the electronic properties of monolayer tellurene flakes deposited on SiO_2/Si (p^+) substrate, we carried out Kelvin-probe AFM measuring the local scale surface Fermi potential of the materials. We observed a striking difference between the local potential of the monolayer tellurene flakes and SiO_2/ Si (p^+) substrate. Our study paves the way to the synthesis of ultra-scaled thin films of tellurium, down to the monolayer limit, for integration into nanotechnological devices, in particular in the resistive switching field.

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