

2D crystals of transition metal trichalcogenides for nanoelectronics and photovoltaics

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Abstract: Unusual electronic properties of single atom thick films of carbon known as graphene sparked the interest of researchers to study other two dimensional materials (2D) in order to find more interesting effects and applications. Since graphene is semi-metal with no bandgap it cannot be directly used to produce small-scale logic elements such as field-effect transistors (FET) or other devices. Now the focus is on the rich family of 2D-materials consisting of transition metal chalcogenides (MoS₂, WSe₂ and TiS₃). Most of them have layered structure with very weak bonds in one crystal direction and could be effectively exfoliated with ultrasonic treatment in liquid medium. Few-layered titanium trisulfide was already studied in FET structures and showed quite high ON/OFF ratio and electron mobility. This material has a bandgap close to 1 eV which needs to be tuned in order to use it for photovoltaics and other applications. Knowing that titanium and zirconium form solid solutions with complete miscibility we synthesized and studied TixZr1-xS3 solid solutions to show a way of tuning the bandgap and producing the materials with the same structure as TiS₃. We studied the morphology and crystal structure of TixZr1-xS3 and found the technique allowing to precisely control the ratio between Ti and Zr which is the key to control the bandgap in this material.