Magnetron Sputtered WS2 Thin Films

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The Unique optical and electrical properties of 2D materials permit many important device applications. One of the most well-known 2D material, graphene attracts attention for semiconductor device applications due to its strong interaction with photons in a broad wavelength range and its high carrier mobility [1-3]. However, field effect transistors produced from graphene cannot be effectively switched off and have low on/off switch ratios due to lack of bandgap [4]. This brings up the importance of other 2D materials at least for the transistors applications. These 2D semiconductors are Transition Metal Dicalcogenides (TMDCs) given by the MX2, M;transition metal (Mo, W, i.e) and X; chalcogenide (S, Se, i.e) [4]. Best known 2D semiconductors materials are MoS2, WS2, MoSe2, WSe2. These materials show very important properties such as indirect-to-direct band-gap transition from monolayer to bulk regime, coupled spin and valley physics, and band structure tunability with strain. Furthermore, the combination of WS2 thin layers with other 2D materials has given rise to a large category of 2D hetero-structures. Changing its properties mainly from a single layer to thick layers makes these materials very suitable for in-situ structural analysis.

Thin films of WS2 were grown by radio frequency magnetron sputtering (RFMS) down to a few layer to 700 nm on different type of substrates in different growth conditions. Effects of growth conditions, such as RF power, temperature of the substrate, thickness, different type of substrates, on the grown thin films were investigated by X-ray diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS), Raman Spectroscopy (RS), Atomic Force Microscopy (AFM), Photoluminescence (PL), and optical absorption measurements. XRD studies showed that growth conditions have huge impact on the material's crystal quality. Peak belong to (002) plane appeared commonly grown at higher RF powers and thicker samples. In addition to the observation of the (002) plane, (10l) and (11l) (l=0,1,2,3) peaks was observed in all of the thin films. Raman scattering measurements showed signal coming from two modes, namely 352 cm-1 and 418 cm-1 corresponding to E2g1 and A1g modes from in plane and out-of plane vibrations, respectively. Binding energy depth profile for W4f7/2 and W4f5/2 is represented for the thin films grown at different condition which showed two satellite peaks settled at 31.5eV and 33.8eV. Deconvolution of the spectrum is to a doublet consisting of S 2p3/2 and S 2p1/2 peaks centered at binding energy values of 161.88eV and 163.18eV. Optical absorption of the films give rise to a 1.2 eV bandgap energy while it is changing when the thickness decreases

References

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Figures

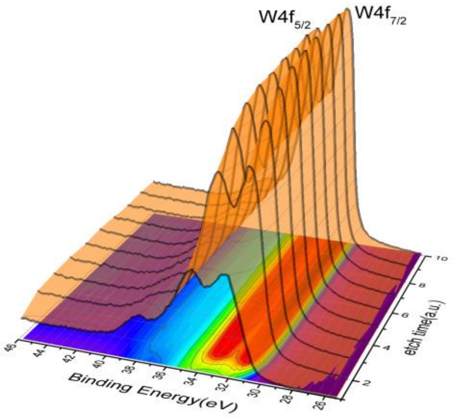

Figure 1. XPS depth profile of the W4f