On Demand

Emerging Materials
Room On Demand - Session EM9
Ternary and Quaternary Materials

EM9-1 Substitutional W Doping of MoS_2 for Threshold Voltage Control of Field Effect Transistor*, **Hwi Yoon,** W. Woo, I. Sohn, Y. Lee, S. Seo, S. Cheong, H. Kim, H. Kim,* Yonsei University, Korea

Two dimensional (2D) layered transition metal dichalcogenides (TMDCs) have attracted great attention owing to its excellent properties such as superior mechanical flexibility, transparency thermal stability, and compatibility to silicon CMOS processes. In particular, molybdenum disulfide (MoS_2) has been extensively studied in recent years. MoS_2 has been considered as attractive channel material for electronic switch device applications in the form of field-effect transistors (FETs) due to superior electrical properties such as thickness-dependent bandgap, high field-effect mobility, high current on/off ratio (>10^8), nearly ideal subthreshold swing (SS). Despite all the advantages of MoS_2 as a promising candidate to replace silicon in such devices, large variations in the threshold voltage (V_{th}) of FET makes difficult it in practical application. The Vth of silicon-based semiconductor technology at the 22 nm technology node is 0.289 V for high performance logic and 0.413 V for low operating power logic. In contrast, values of Vth of back-gated MoS_2 FETs being reported vary from −30 V to 40 V. In the case of Si-based FET, V_{th} can be easily tuned by doping through ion implantation. However, this method cannot be applied to MoS_2 because energetic processes such as implantation, plasma easily cause damage to MoS_2. In this study, we developed one-step doping process during chemical vapor deposition (CVD) of MoS_2. electrical properties such as carrier density, bandgap and chemical composition tuned according to dopant concentration. In addition, V_{th} modulation of MoS_2 was carried out by using substitutional doping of W. V_{th} of MoS_2 FET has decreased by more than 10 V after doping.

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EM9-2 Atomic Layer Deposition of $CuSn_XS_Y$ from Low-Cost Precursors and Its Optical and Electrical Characteristics*, **Jakub Ostapko,** G. Kołodziej, M. Wlazło,* CBRTP - Research and Development Center of Technology for Industry, Poland*; Z. Starowicz,* Institute of Metallurgy and Materials Science, Poland*; G. Putynkowski,* CBRTP - Research and Development Center of Technology for Industry, Poland

Metal sulfides are of high importance for thin-film photovoltaics applications. Some of the most widely studied structures belong to the quaternary compounds group and play the role of solar cell absorber: CIGS ($CuIn_{(1-x)}Ga_xSe_2$) and CZTS (Cu_2ZnSnS_4). The ternary structure, Cu_2SnS_3 (CTS),[1] has been reported in the literature as a simplified and potential absorber material. Ordinarily, methods different than ALD are used for their synthesis. In case of record CIGS[2] (23.35% efficiency) and CZTS[3] (12.6%) cells, DC sputtering and solution approaches were used, respectively.

ALD is dedicated to the preparation of uniform thin films. There are a few reports in the literature concerning ALD synthesis of technologically important ternary[4–8] and quaternary[9] sulfides. The ALD synthesis of sulfide-based absorbers is hindered by some limitations: precursor chemical compatibility, including reactivity with the sulfur precursor, parasitic reactions, and the limited volatility of precursors. These limitations are reflected by low growth per ALD cycle. The other aspects that limit ALD utility are high moisture and oxygen sensitivity, and high prices of commercially available metal precursors.

In this study, a new process of ALD deposition of ternary sulfide $CuSn_xS_y$ is presented. The material has been prepared using affordable copper and tin precursors. This is contrasted with the reported ALD processes, which use expensive organometallic reactants as sources of Cu and Sn. The synthesis has been carried out at low temperature. Films of $CuSn_xS_y$ varying in stoichiometry were synthesized. Film morphology, including cross-section imaging, was provided by SEM analysis. The elemental composition was determined by EDS. The results of optical (UV-vis spectroscopy) and electrical measurements (Hall effect, four-point probe) are presented and discussed in the context of the photovoltaic application of ALD synthesized $CuSn_xS_y$ films.

The obtained results highlight the versatility of the ALD technique and provide an example of a cost-effective synthesis of thin-film absorber material.

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