Growth Behaviors and Structural Characterization of PEALD In_2O_3 thin films using Amide-based and Alkyl-Based Novel Indium Precursors

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Abstract text

Oxide semiconductors are attracting attention as active channel materials due to their advantages like high field effect mobility, low off current, and low process temperature. Indium-based oxides, such as In-Ga-Zn-O (IGZO), In-Ga-Sn-O (IGTO), In-Ga-O (IGO), have been mainly studied for high electrical characteristic. Indium oxide is critical source in electron properties because it has very low electron formation energy that can easily generate electron. Indium provides carrier transport path through overlap from the large size of their 5s orbital. As the device scaling down according to Moore's law need nanoscale controlling in process, the atomic layer deposition (ALD) is powerful method which can control film thickness in atomic scale and can control chemical composition. Since ALD process is based on self-limiting reaction nature, choice of precursor has significant influence on the properties of thin film. Many indium precursors ($InCl_3$, TMIn, InCp, DADI, In-CA-1, etc.) for ALD have been developed. Especially, (3-Dimethylaminopropyl) dimethylindium (DADI) is mostly used precursor in developing oxide semiconductor. The DADI precursor which is liquid phase has moderate GPC because amine ligand has high reactivity, but it is expensive and has low vapor pressure. In contrast, TMIn is inexpensive and high vapor pressure precursor than DADI, but it is a solid phase material that make low growth rate properties. So that, researching the cheaper precursor that have high reactivity and high growth rate is needed. In this study, we newly synthesized two indium precursors of DIP-3 and DIP-4 based on structure of DADI and TMIn, respectively. DIP-3 is liquid phase precursor based on DADI that have structure that is consist of amine ligand and coordination bond. On the other hand, DIP-4 is Alkyl based liquid phase material like TMIn. DIP-4 has not only higher vapor pressure compared to DIP-3 but also advantage in price. We made indium oxide film using DIP-3, DIP-4 and O_2 plasma in setting temperature 100 ~ 300˚C. As a result, indium oxide layer using DIP-4 precursor has higher GPC (~1 Å/cycle) than DIP-3 (~0.6 Å/cycle). In addition, enlarged grains that help to enhance electrical properties are found from sample using DIP-4 due to smaller precursor size. We explain the origin of difference through analysis of film and DFT calculation. Therefore, it is useful method to get enhanced GPC and enlarged grain size that changing structure of precursor.

Reference

[1] Hong, TaeHyun, et al. "Structural, optical, and electrical properties of InO x thin films deposited by plasma-enhanced atomic layer deposition for flexible device applications." ACS Applied Electronic Materials 4.6 (2022): 3010-3017.

Supplemental Document

Figure 1a, b show the ALD Growth Properties and Crystallinity of two precursors. DIP-4 has Higher growth rate than DIP-3, and its Roughness is almost Twice than DIP-3.

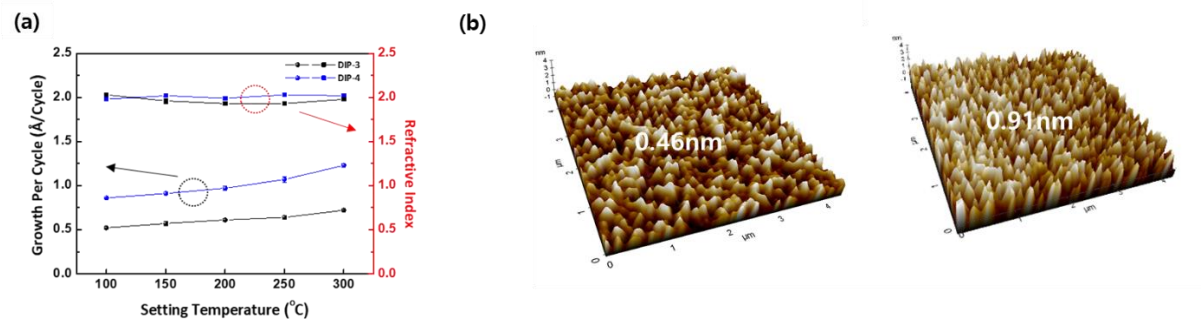

Figure 1. (a) ALD Growth Rate according to Process temperature. (b) Roughness of Indium oxide film Using DIP-3 (left), DIP-4 (right)