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Key Materials Issues in Co-Sputtered Aluminium-Gallium Oxide Films and Their Applications to Solar-Blind Photodetectors

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A wider bandgap material possesses great merit as it allows the design of devices such as high sensitive wavelength-tunable photodetectors (PDs). Aluminum element is a candidate to enlarge the bandgap of Ga2O3 since Al2O3 has a larger bandgap. The similar electron structures of Al and Ga makes the (AlGa)2O3 alloy possible to achieve. Therefore, by incorporating Al2O3 into Ga2O3, the bandgap of aluminum-gallium oxide (AGO) materials can be modulated toward a higher value (commonly 5~7 eV), which expands its deep ultraviolet (DUV) applications. In this study, the wide-bandgap AGO thin films were grown on sapphire by co-sputtering of Al and GaO targets, which were used DC and RF powers, respectively. The RF power for the GaO target was fixed at 100 W. Various DC powers of 5, 10, 30, 50, and 70 W were employed for the Al target. The substrate temperature and AGO thickness were kept at 600 ℃ and 120 nm, respectively. Moreover, the pure Ar and O2 gases were introduced into the growth chamber at a constant [O2/(Ar + O2)] partial pressure of 16%, and the working pressure was fixed at 5 mTorr. Additionally, the as-deposited AGO films were annealed at 900 ℃ for 20 min in air. The AGO films deposited at the Al sputtering power of 5-50W presented single crystalline phase with AGO(-201)-family diffraction peaks. However, as the Al sputtering power was increased to 70 W, the AGO film was amorphous. In addition, the energy gap (Eg) values can be obtained via their transmittance spectra. As the Al sputtering powers were 5, 10, 30, 50, and 70 W, the Eg values of AGO films were determined to be 5.06, 5.10, 5.13, 5.19, and 5.24 eV, respectively. Furthermore, the AGO films grown at the Al sputtering power of 5-30 W were selected to prepare the metal-semiconductor-metal PDs. As a 20-V bias was applied, the device fabricated with AGO film using the Al sputtering power of 10 W has better performance, where its dark current and responsivity are 1.8 × 10−12 A and 0.37 A/W, respectively. By adjusting the growth conditions of AGO films, the performance of PDs will be improved and presented in this work.

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