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Thick $In_xGa_{1-x}N$ Films Prepared by Reactive Sputtering with Single Cermet Targets

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$In_xGa_{1-x}N$ films with x = 0, 0.25, and 0.5 were grown on SiO_2/Si(100) substrates by reactive sputtering at 200°C for 90 min with single cermet targets made by hot pressing a powder mixture of metallic indium and gallium and gallium nitride. After alloying with In, InGaN showed preferential $(10\bar{1}0)$ diffraction, smooth surface with roughness less than 1.80 nm, reduced mismatch with the Si substrate, enhanced electron mobility above 7 $cm^2\ V^{-1}\ s^{-1}$, and blue and green light-emitting capabilities.

Key words: $In_xGa_{1-x}N$, thin film, sputtering, electrical properties

INTRODUCTION

III-nitride semiconductors such as AlN, GaN, InN, and their alloys have been widely used in device applications. GaN and InGaN with ultraviolet (UV) or blue light-emitting capability have been applied for white-light lighting. GaN has a bandgap (E_g) of 3.4 eV. The E_g value of InGaN changes from 3.4 eV to 0.65 eV on alloying InN[1,2] into GaN, covering the light wavelengths from the near-ultraviolet to infrared range. Thick GaN film has been grown on AlN-coated sapphire substrates before multiple quantum wells for quality considerations. So far, GaN and InGaN layers have been deposited by metalorganic chemical vapor deposition (MOCVD)[3–5] and molecular-beam epitaxy.[6–8] For MOCVD, InGaN films grown at 550°C to 900°C use trimethylindium (TMIn), trimethylgallium (TMGa), and NH_3 as reaction precursors and N_2 as carrier gas. The high capital cost and process temperature and the utilization of dangerous precursors are the major concerns with the MOCVD process.

Sputtering technique can provide an approach with low process temperature, large-area fabrication, and using safe precursors. However, reports of III-nitride films prepared by sputtering are few. GaN films have been deposited by direct-current (dc) and radio-frequency (rf) sputtering at 400°C to 700°C with a molten Ga target[9,10] and by rf sputtering at room temperature with a GaN target.[11] Shinoda et al.[12] grew sputtered GaN, InGaN, and AlGaN films at 600°C to 850°C with three different targets of pure Ga, 15%In-85%Ga, and 15%Al-85%Ga, respectively, in (Ar + N_2) atmosphere. The 85% Ga-containing alloy targets will behave viscously because their eutectic temperature is lower than 30°C. Guo et al.[13] fabricated InGaN thin films by reactive sputtering at 100°C to 550°C with a GaAs wafer-attached In target in nitrogen atmosphere. Their pure InGaN thin film without arsenic was only obtained at the deposition temperature of 550°C. In our previous study, InN film was grown by rf sputtering at 150°C to 300°C with an In target.[14]

III-nitride films made by sputtering with targets of Ga and Ga alloys have been deposited above 400°C. Pure and dense GaN targets for nitride film are difficult to fabricate due to the high melting point of 2500°C, sensitivity to high-temperature oxidation, and easy sublimation. To avoid the problems of using a viscous target and high-temperature densification, in this work, we demonstrate deposition of GaN and InGaN films by rf sputtering at 100°C to 400°C with a single cermet

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