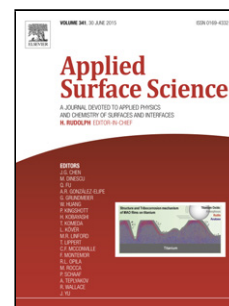


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Effects of pre-annealed ITO film on the electrical characteristics of high-reflectance Ni/Ag/Ni/Au contacts to p-type GaN

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Abstract: In this study, a Ni/Ag/Ni/Au multilayer with first Ni layer of 0.5 nm was first optimized for high reflectivity (92.3%), low specific contact resistance ($2.1 \times 10^{-3} \Omega \text{cm}^2$) and good attachment strength to p-type GaN. To further decrease the contact resistance, the p-type GaN surface was previously treated with pre-annealed indium-tin-oxide (ITO) film before deposition of the Ni/Ag/Ni/Au multilayer, and resulted in a lower specific contact resistance of $1.9 \times 10^{-4} \Omega \text{cm}^2$. The X-ray photoelectron spectroscopy results indicated that Ga 2p core level of the p-type GaN surface with the pre-annealed ITO film had a lower binding energy, leading to a reduction in the contact resistance. Furthermore, GaN-based flip-chip light-emitting diodes (LEDs) with and without the pre-annealed ITO film were fabricated. The average forward voltage of the flip-chip LEDs fabricated with the pre-annealed ITO film is 3.22 V at an injection current density of 35 A/cm^2 , which is much lower than that (3.49V) of flip-chip LEDs without the pre-annealed ITO film. These results reveal that the proposed approach is effectively to fabricate high quality p-type contacts toward high power GaN-based LEDs.

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Keywords: GaN; Ohmic contact; Pre-annealed ITO film; Flip-chip LED.

1. Introduction

High power GaN-based light-emitting diodes (LEDs) have recently attracted much attention due to their important applications especially in solid-state lighting [1]. However, it is well known that conventional GaN-based LEDs on sapphire substrates are suffered from serious problems, such as high forward voltage drop and poor heat dissipation when operated under high current density. To obtain high power LEDs, flip-chip and vertical-structure LEDs with higher light extraction efficiency and better heat dissipation have been exploited [2-3]. In these two types of LEDs, fabrication of p-type contact with a low resistance and high reflectivity is especially crucial. Silver (Ag) has been widely

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