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Current Spreading Layer with High Transparency and Conductivity for near-ultraviolet light emitting diodes

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***Abstract*— Transparent conductive aluminum-doped zinc oxide (AZO) layer was deposited on GaN-based near-ultraviolet (NUV) light emitting epitaxial wafers as current spreading layer by a sputtering process. Efforts were made to improve the electrical properties of AZO in order to produce ohmic contact.**

Keywords— near ultraviolet light emitting diodes; transparent conductive current spreading layer; aluminum-doped zinc oxide

I. INTRODUCTION

Transparent conductive current spreading layer (CSL) is more advantageous in improving light extraction efficiency for NUV LEDs than conventional Ni/Au and indium tin oxide (ITO) is a widely used transparent conductive CSL for LEDs. However, ITO is expensive because of its In-content [1] while AZO is a well-known alternative candidate to ITO since it has similar electrical and optical properties but is low-cost, nontoxic and more stable at high temperatures [2]-[3]. There has been very few research reported on using AZO-based reflective CSL for GaN-based NUV LEDs with flip-chip configuration. Hence, this work focuses on modifying electrical behavior of AZO on p-GaN to produce ohmic contact. In the future, AZO-based CSL will be used together with Al reflector to form AZO-based reflective CSL in flip-chip NUV LED application.

II. EXPERIMENTS AND RESULTS

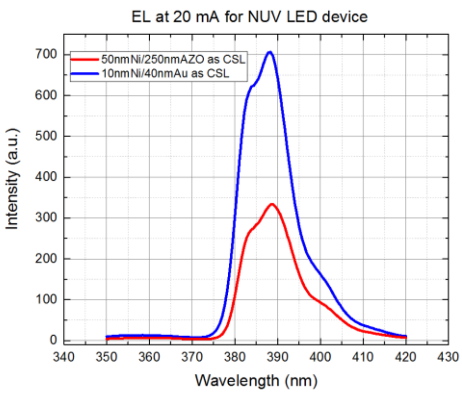

Fig. 1. EL of LEDs with different CSLs

Six types of AZO-based CSLs including as-deposit 110nm AZO, annealed 110nm AZO, annealed 5nm Ni/ as-deposit 110nm AZO, annealed 5nm Ni/ annealed 110nm AZO, annealed 5nm Ni/as-deposit 250nm AZO and annealed 5nm Ni/annealed 250nm AZO were fabricated on the mesas of NUV LED wafers. Ni and AZO were deposited by e-beam evaporation and DC sputtering respectively. After deposition, Ni was annealed in air at 550 ℃ for 5 min. 110nm AZO and 250nm AZO were annealed at 550℃ for 5min in N_2 and at 800℃ for 1min in N_2 respectively.

I-V measurement was carried out on the 6 types of CSLs. In the end, annealed 5nm Ni/annealed 250nm AZO gives the best I-V properties since it almost presents ohmic behavior. One NUV LED device with annealed 5nm Ni/annealed 250nm AZO as its CSL was fabricated and its electroluminescence (EL) graph together with that of an LED using conventional Ni/Au CSL were displayed in Figure 1. The EL intensity of the LED with Ni/AZO is weaker than that of the LED with Ni/Au due to the high specific contact resistivity of Ni/AZO.

III. SUMMARY

I-V behavior of CSLs with different compositions, AZO thicknesses and annealing conditions were tested and compared. The annealed 5nm Ni/annealed 250nm AZO presents the best electrical properties. Afterwards, an NUV LED with transparent conductive Ni/AZO was fabricated. Although EL can be observed, its intensity is still lower than that of the LED with Ni/Au. This is because the contact between Ni/AZO and p-GaN is not perfect ohmic indicating much larger specific contact resistivity than that of Ni/Au. Although Ni/AZO possesses higher transparency than that of Ni/Au, its electrical behavior still needs further modification.

ACKNOWLEDGMENT

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