ITO and NiO_x/ITO off-axis PVD deposition for transparent contact application

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ITO (Indium Tin Oxyde) is an optically transparent and electrically conductive material. It is mainly used as a spreading layer for optoeleconics devives such as LED, laser or µ-display. Concerning µ-display, blue and green native colors are obtained on GaN epitaxial layers. Even if N-type contact growth on these materials is well documented in the literature, obtaining a transparent P-type contact remains a key challenge to perform device integration and obtain best performances of µLED devices. Direct ITO deposition on the p-GaN surface is one way to obtain such P-type contact [1-3] whereas NiO_x / ITO bilayer stack seems a promising way to reach high-performance contact [1,4]. Present study will describe results obtained for both ITO and Ni/ITO deposition with an off-axis multiple-cathode Physical Vapor Deposition (PVD) chamber , Clover® on Endura™ 300mm platform from Applied Materials.

ITO deposition studies were performed on silicon 300mm wafer. Firstly, ITO films optoelectrical properties obtained by an ITO target, we will be described in regard with their deposition temperature, power supply and film thicknesses. For the last one the electro-optical properties are shown in Fig.1 and there is clearly an optimum thickness for the film best performances in the limit required by a transparent contact. In a second part, ITO compositions fine tuning through PVD co-sputtering will be addressed. Optical, electrical and chemical characterizations will be discussed to better understand the link between ITO composition and material performance.
Ni (x nm) / ITO (20 nm) bilayers were growth by PVD in Clover chamber. Annealing impact (atmosphere, temperature) on the bilayer's opto-electrical and depth composition were studied. Fig. 2 clearly shows that some conditions are favourable to obtain an NiO_x highly transparent interfacial layer between the ITO and the substrate. Concerning the Rs, high increase with O_2 annealing is observed whereas a very low increase under N_2 annealing and an improvement with Ar annealing are obtained.

Finally, TLM (Transfer Length Method) test-vehicle have been used to evaluate the specific contact resistivity of the p-type GaN / contact interface. Results obtained enabled to evaluate the link between ITO or bilayer composition and the electrical interface properties. Considering the material optical transmission, it allows to evaluate the best adapted process that could be used for a µ-LED device to improve his performances.

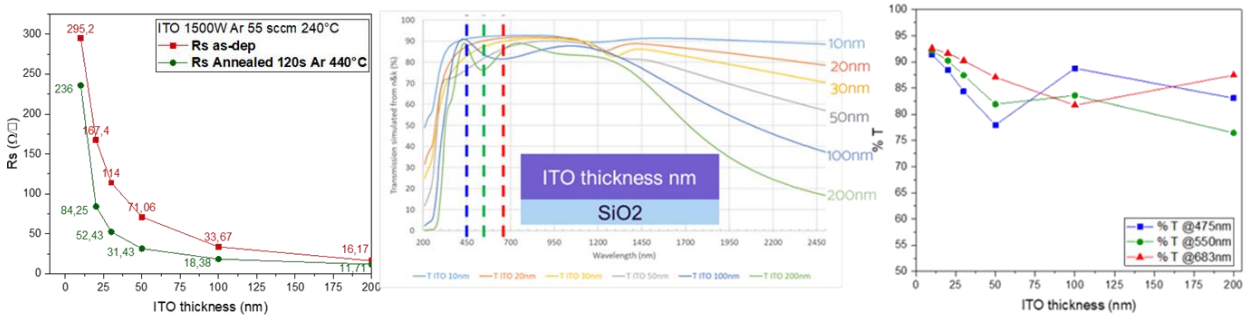

Figure 1: left: sheet resistance (Rs) values for different ITO thicknesses before and after annealing; right: optical transmission values vs ITO thickness, and summary of the values for blue / green / red light wavelengths.

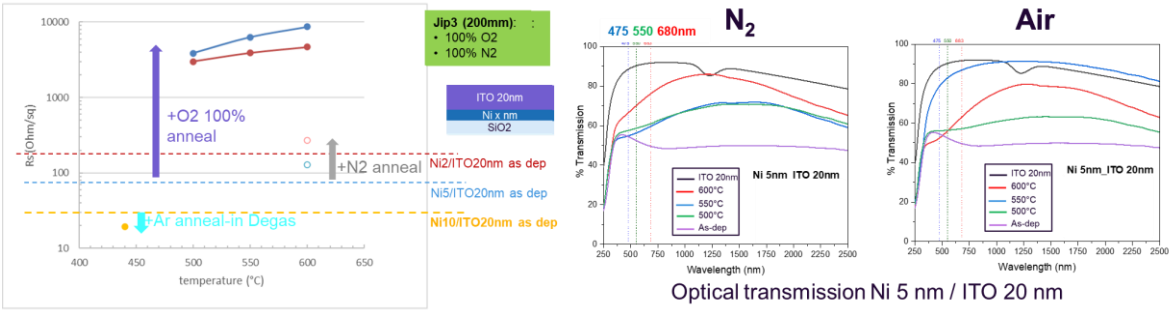

Figure 2: sheet resistance (Rs) variation and optical transmission for the Ni (x nm) / ITO (20 nm) bilayer as function of annealing atmosphere and temperature.

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References

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