Recent findings on Ohmic and Schottky contacts to β-Ga_2O_3

Giuseppe GRECO, Filippo Giannazzo, Fabrizio Roccaforte - CNR-IMM, CATANIA, ITALY

Ferdinando Iucolano – STMICROELECTRONICS, CATANIA, ITALY

Nowadays, Beta Gallium Oxide (β-Ga_2O_3) is considered a revolutionary material in the field of ultra-wide-bandgap (UWBG) semiconductors due to its exceptional electrical and optical properties. The large bandgap about 4.8 eV, extremely high critical electric field above 6 MV/cm and relative adequate electron mobility of 200 $cm^2V^{-1}s^{-1}$, make this material very promising for next generation of high power devices beyond silicon carbide and gallium nitride [1]. In this context, the achievement of well-established Ohmic and Schottky contacts represents a crucial element for real exploitation of Ga_2O_3 technology and the effective fabrication of power device based on this material [2].

According to the Schottky-Mott rule, for n-type semiconductor, the use of metal with low work function (Φ_m) is crucial to obtain moderated barrier height (Φ_B), especially in material with a high electron affinity as the Ga_2O_3 (χ ~ 4 eV). In n-type doped Ga_2O_3, the Ti (Φ_m = 4.33 eV) is usually selected as the metal in contact with the Ga_2O_3, and Ti/Au annealed in the range of 400-500°C are typically used to achieve Ohmic contact. During the annealing, the Ti reacts with Ga_2O_3 resulting in a defective Ga_2O_3 layer close to the interface and a thin TiOx layer above, both enhancing the electrons transport through the metal Ga_2O_3 metal/barrier [3]. Nevertheless, the exact Ohmic contact formation mechanism to β-Ga_2O_3 is still not clear. In order to improve and facilitate the Ohmic contact formation several approaches have been proposed as implantation, oxide interlayer incorporation (ITO, AZO), selective plasma process or crystal-regrowth. On the other hands, to obtain Schottky contact on Ga_2O_3, many different metals have been investigated (Cr, Cu, Mo, Co, Ni, Ir, Pd, Au) [2]. Large work function metals such as Pd, Au and Pt, results in metal/Ga_2O_3 interface with high $\Phi_{B,}$ also if a certain Fermi level pinning has been observed for some surface orientation.

In our work, Ohmic contact formation has been achieved by using a Ti /Au bilayer on the back side of a β-Ga_2O_3 substrate. A greater difficulty was encountered to obtain Ohmic contacts on the front side. Here, alternative approach based on surface plasma process have been investigated, leading to promising results. Rather, for Schottky contact, Ni/Au metal solution has been investigated on low doped (001) Ga_2O_3 epilayer. The fabricated Schottky diodes display electrical characteristics with a non-negligible non-uniformity in both forward and reverse configuration, with an average ideality factor and barrier height of 1.51 and 0.98 eV. These values greatly improve after the annealing at 400 °C with the ideality factor which decreases to 1.19 and the barrier height which increases to 1.25 eV. A similar improving has been observed in the reverse characteristic with the leakage current measured at V_R=-40 V which decreases from about 1×10^{-3} to 4.7×10^{-7} A/cm^{-2} after annealing at 400 °C. This achievement demonstrated how the properties of the metal/Ga_2O_3 interface are important for the obtainment of a reliable Schottky contact on Ga_2O_3.

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