Comparison of Thermal and ArF Excimer Laser Activation of Mg-doped GaN

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Excimer laser annealing has recently been proposed as an alternative to thermal annealing in the activation of Mg-doped GaN devices [1-2]. Compared to conventional thermal annealing where the entire wafer is subjected to high temperature (in the order of 800°C), laser annealing can be used to anneal a small target area (localized activation), which can be useful in fabricating complex device geometries. In addition, only the top epitaxial layers are annealed for laser annealing, which can reduce the thermal stress to the substrate. This study aims to investigate the effectiveness of ArF (193nm) laser annealing in the activation of Mg-doped GaN and compare this to conventional rapid thermal annealing (RTA).

The wafer configuration used in this study is composed of thick unactivated Mg-doped GaN, and undoped GaN on sapphire substrate [Fig. 1(a)]. The Mg-doping concentrations are varied from 10^{17} to 10^{19} cm^{-3}, which are designed to measure effectively the Mg-GaN activation. For reference, thermal annealing of the wafers was done at 500 to 800°C for 2mins using RTA under nitrogen ambient. On the other hand, for laser annealing, a Hall structure will be used [Fig. 1(b)], which would ensure consistent laser alignment during annealing. The fabrication of the Hall structure will be done using standard photolithography, and the Hall mesa will be defined using dry etcher. The sample resistivities are measured using Van der Pauw method.

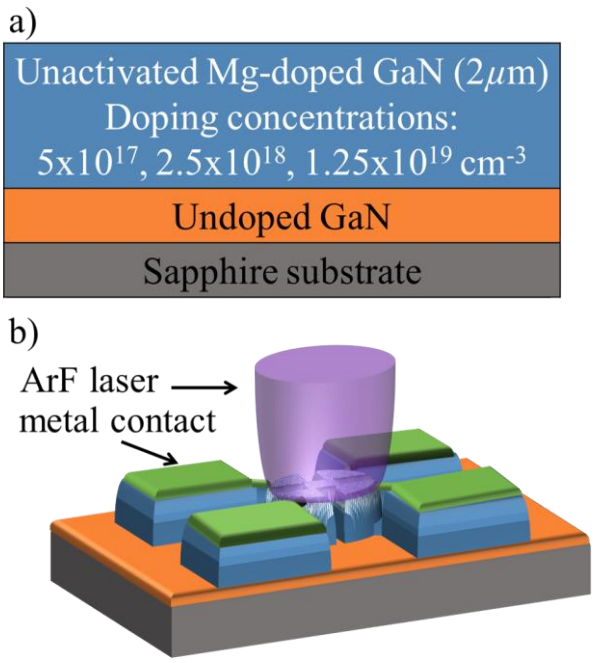

Figure 1. (a) wafer used with different Mg-doping concentrations and (b) the Hall measurement device structure for laser annealing.

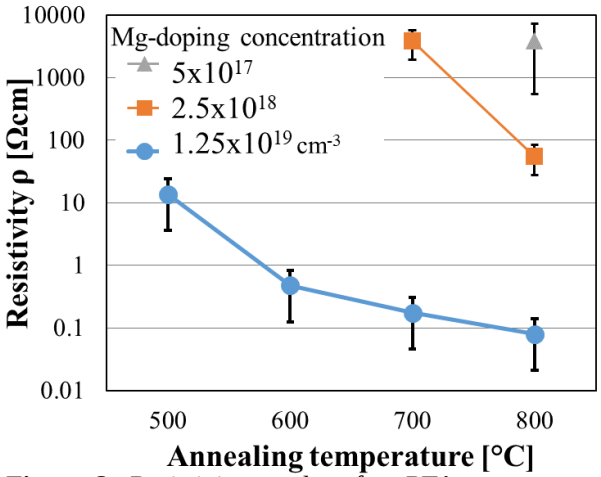

Figure 2. Resistivity results after RTA treatment at different temperatures.

Shown in Fig. 2, is the reference data for sample resistivity using RTA process. The resistivity generally decreases with annealing temperature from 500 to 800°C. This suggests more Mg activation at higher temperature. In addition, the resistivity decreases with increasing nominal Mg doping. The lower Mg doping concentration wafers (10^{17} and 10^{18} cm^{-3}) have high resistivities than the measurement limit of our set-up, thus no data at low temperature for these wafers were measured. The data for the samples using laser annealing will be presented in the conference. In conclusion, the study aims to investigate the effectiveness of ArF laser annealing and compare this to conventional RTA process for activation of Mg-doped GaN.

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Reference: [1] N. Kurose *et al.*, AIP Advances **8**, 015329 (2018). [2] P. Kozodoy *et al.*, J. Appl. Phys. **87**, 1832 (2000).