Low Resistance Non-alloyed Ohmic Contacts to High Al Composition n-type AlGaN

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Introduction

The AlGaN ultrawide-bandgap material system has attracted research interest for electronic applications due to its large breakdown field and ultraviolet photonic applications due to its large direct bandgap, both of which require low-resistance metal-semiconductor contacts. Ohmic contacts to high (>70%) Al content n-type $Al_xGa_{1-x}N$ layers are typically fabricated by a lift-off process and high temperature (>700°C) thermal alloying. These conditions often result in significant structural deformations of the fabricated structures and impose a harsh thermal budget on all other aspects of the device. Here, we report the fabrication *non-alloyed as-deposited* ohmic contacts to 71% n+AlGaN ($E_g \sim 5.4$eV) with linear *I-V* characteristics and a contact resistivity of $\rho_c = (4.4\pm1.0)\times10^{-4}\ \Omega cm^2$ (measured at zero voltage), achieved by mitigating the degree of carbon contamination at the metal-semiconductor interface.

Experimental Procedures

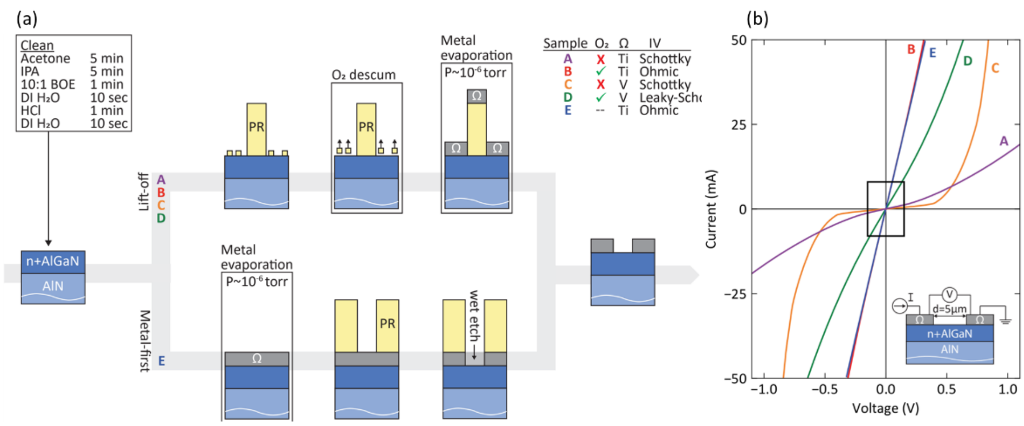
400 nm thick n+AlGaN layers were grown by molecular beam epitaxy on single-crystal AlN substrates. Hall characterization revealed a free carrier concentration of ~7×10^{19} cm^{-3} and a resistivity of 4 - 5.5 mΩ cm (among the lowest reported for $Al_{0.71}Ga_{0.29}N$). Metal-semiconductor contacts were formed on the as-grown surfaces by two fabrication schemes: (1) Tradition photoresist lift-off procedure with and without an O_2 asher descum using Ti- and V-based metal stacks; (2) A Ti-based metal-first procedure patterned by a metal wet etch.

Results and Discussion

C-TLM measurements of all samples were performed at room temperature. Two fabrication schemes exhibited linear IV characteristics and contact resistivities (extracted at zero voltage) of ~10^{-4} Ωcm^2: metal-first Ti-based contacts and Ti-based contacts fabricated by a lift-off procedure with an O_2 asher descum. All V-based contact stacks and contacts fabricated by a lift-off procedure without oxygen descum exhibited Schottky-like IV characteristics. These results suggest that proper removal of carbon on the AlGaN interface is critical to forming low-resistance contacts.

Acknowledgement

This work was supported in part by the DARPA UWBGS program under Award No: HR001123S0051-FP-26, ULTRA, an Energy Frontier Research Center funded by the U.S. Department of Energy (DOE), Office of Science, Basic Energy Sciences (BES), under Award No. DE-SC0021230, and by SUPREME, one of seven centers in JUMP 2.0, a Semiconductor Research Corporation (SRC) program sponsored by DARPA. This work was performed in part at the Cornell NanoScale Facility, a member of the National Nanotechnology Coordinated Infrastructure (NNCI), which is supported by the National Science Foundation (Grant NNCI-2025233).



(a) Fabrication scheme for lift-off (top) and metal-first (bottom) ohmic contact formation. (b) I-V characteristics of C-TLM structures with a 5 μm gap and 120 μm inside radius. The Ti-based metal-first and descummed lift-off samples exhibit linear I-V characteristics.