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Abstract

"MOVPE Growth and Characterization of ZnO Properties for Optoelectronic Applications"

A new Metalorganic Vapor Phase Epitaxy (MOVPE) method was developed for the growth and doping of high-quality ZnO films in this work. ZnO is a unique optoelectronic material for the effective light generation in the green to the UV spectrum range.

Optoelectronic applications of ZnO require impurity-free monocrystalline films with smooth surface and low concentration of the defects in the crystal lattice. At the beginning of this work only few reports on MOVPE growth of polycrystalline ZnO existed. The low quality of ZnO is attributed to the lack of the epitaxially matched substrate, and the gas-phase prereactions between the Zn- and O-precursors. To achieve control over the ZnO quality, several O-precursors were tested for the growth on GaN/Si(111) or GaN/Sapphire substrates at different reactor temperatures and pressures. ZnO layers with XRD rocking curve FWHMs of the (0002) reflection of 180″ and narrow cathodoluminescence of 1.3 meV of the dominant I_8 emission were synthesized using two-step growth. In this procedure, ZnO is homoepitaxially grown at high temperature using N_2O as O-precursor on the ZnO buffer layer. The buffer layer is grown at low temperature using tertiary-butanol as O-precursor.

Naturally a n-type semiconductor, ZnO can hardly be doped to become a p-type. This doping asymmetry represents an issue for ZnO-based devices. Beginning from 1992, a growing number of reports have been claiming a fabrication of p-type ZnO, but the results are still questionable. Native defects, the non-stoichiometry, and hydrogen are the sources of n-type conductivity of ZnO. Together with a low solubility of the dopants and deep position of the impurity levels, these factors partly explain p-type doping difficulty in ZnO. However, there is no fully described mechanism of the ZnO doping asymmetry yet.

In this work, NH_3, unsymmetrical dimethylhydrazine (UDMHy), diisobutylamine, and NO nitrogen precursors were studied for doping of ZnO. Some NH_3– and UDMHy-doped samples have shown a reduction in the electron concentration after post-growth rapid thermal annealing, but no reliable p-type conductivity was observed. The use of NO precursor results in very smooth layers with a strong drop in growth rate. However, it does not influence the optical and electrical properties of the ZnO. Diisobutylamine deteriorates the properties of ZnO and does not lead to nitrogen incorporation. A brownish color of the samples is observed when using NH_3 or UDMHy. From the strong reduction in the carrier concentration about one order of magnitude lower than the background doping concentration, and the behavior of the DAP luminescence, it is concluded that nitrogen as an acceptor can be successfully introduced in ZnO using UDMHy.