Fabrication and surface-leakage suppression in (non-polar) m-Zn(Mg)O optoelectronic devices

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Zincoxide is a rather new material system for mid-infrared (mir) and THz optoelectronic devices like quantum cascade lasers (QCLs) and detectors (QCDs). It is a promising candidate for overcoming cryogenic-operation only and allowing high-temperature devices, due to its twice as large LO-phonon energy as compared to the standard material system of GaAs. Especially, its m-plane orientation is very interesting for designing and realizing the complex structure of QCLs/QCDs, since it is a non-polar crystallographic orientation with no internal fields as compared to regular c-plane devices.
In this work we present a novel fabrication scheme for such m-plane optoelectronic devices including: analysis of various etching techniques (e.g. dry vs wet etching, CH_4- vs $SiCl_4$-based etching), surface treatment and heterostructure design criteria for surface leakage current suppression by multiple orders of magnitude and optimized low resistance Ohmic contacts (contact resistivities of ~10^{-5} Ω x cm^2).
A detailed structural analysis and characterization of the fabrication steps and a comparison to similar structures for other epitaxial Zn(Mg)O orientations and device types from literature, reveals an optimized and high quality fabrication scheme. This includes e.g. fabrication yielding up to more than 80% of operational devices for hundreds of QCDs on a single chip. Together with the ability to reproducibly fabricate high-performance m-ZnO/ZnMgO devices for a wide Mg-range between 5% and 30%, it opens a large toolbox for optoelectronic devices based on this novel material system.

Zincoxide is a rather new material system and promising candidate for mid-infrared (mir) and THz optoelectronic devices like quantum cascade lasers (QCLs) and detectors (QCDs) due to its twice as high LO-phonon energy as GaAs. The non-polar m-plane orientation allows designing and realizing such complex devices without internal electrical fields.
We present the full fabrication scheme of such QCL/QCD devices including novel optimized etching techniques, surface leakage current suppression by multiple orders of magnitude and low resistance Ohmic contacts (~10^{-5} Ω x cm^2). Optimized fabrication schemes resulted in fabrication yielding up to more than 80% of operational devices.