Fabrication of ZnO-based Resonant Tunneling Diodes for Quantum Cascade Structures

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The terahertz (THz) spectral range (λ ~ 30µm – 300µm) is also known as the "THz-gap" because of the lack of compact semiconductor devices. Various real-world applications would strongly benefit from such sources like trace gas spectroscopy or security screening. A crucial step is the operation of THz-emitting lasers at room temperature.

Current devices, of which GaAs-based quantum cascade lasers (QCLs) are the most promising ones, lack significant improvements within recent years concerning their maximum operating temperature. They are limited by the parasitic, non-optical LO-phonon transitions (36meV in GaAs), being on the same order as the thermal energy at room temperature (kT = 26meV). Promising candidates to solve this problem include materials like ZnO with their larger LO-phonon energy (E_{LO} = 72meV). To master the fabrication of ZnO-based QC structures, a high quality epitaxial growth is crucial together with a well-controlled fabrication process including (selective) ZnO/ZnMgO etching, and the deposition of low resistance ohmic contacts.

Our devices are grown on m-plane [10-10] ZnO-substrate by molecular beam epitaxy (MBE) and patterned by reactive ion etching (RIE) in a CH_4-based chemistry into 100µm square MESAs. The CH_4-process protects the mask by an amorphous carbon-layer, which increases the selectivity of the etching process [1].

Resonant tunneling diode structures are investigated in this geometry and are presented including different barrier- and well-configurations. We extract contact resistances of 8e-5 □ cm^2 for un-annealed Ti/Au contacts and an electron mobility of above 130cm^2/Vs, both in good agreement with literature.

Demonstrating resonant electron tunneling in ZnO/ZnMgO structures is one of the crucial building blocks for a QCL.

[1] S.-W. Na, M. H. Shin, Y. M. Chung, J. G. Han, and N.-E. Lee, "Investigation of process window during dry etching of ZnO", J. Vac. Sci. Technol. A 23, 898 (2005).

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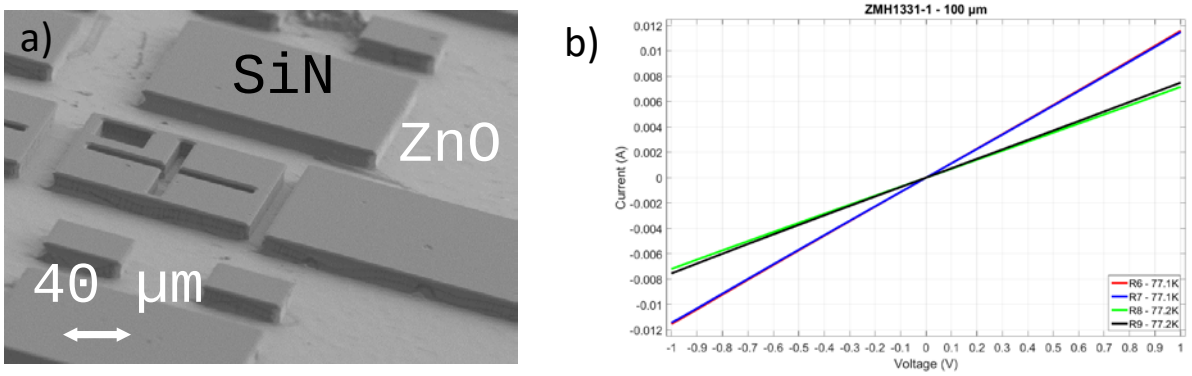

Fig. 1: a) Typical ZnO MESA RTD structures after fabrication. B) Exemplary IV-curve of a 100 µm square MESA RTD structure at liquid nitrogen temperatures.