THz RADIATION SOURCE THROUGH PERIODICALLY MODULATED STRUCTURES

PROF. DR. ERICH GORNIK

INSITUT FÜR FESTKÖRPERELEKTRONIK
TECHNISCHE UNIVERSITÄT WIEN
FLORAGASSE 7
A- 1040 WIEN
AUSTRIA

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E. Gornik, W. Boxleitner, G. Ploner, G.Strasser

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Institut für Festkörperelektronik
Technische Universität Wien
Floragasse 7
A-1040 Wien, Austria

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Further progress has been achieved in the understanding of carrier injection into superlattices. We were able to calculate the current in a two terminal and three terminal device. In the two terminal device a strong temperature dependence of the injected current is found which depends mainly on the Fermi level in the emitter. With increasing temperature a high current level is possible. The calculated current values for the three terminal device do also agree quite well with the experimental values. This is a very encouraging result.
The systematic studies of quantum wires have been continued. A clear dependence of wire mobility and subband spacing on etching procedure has been found. In the next periods new schemes as f.e. side gate techniques will be persued to improve the wire quality and the subband spacings.

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The first step on the way to a DC-driven Bloch oscillator or a plasma driven oscillator is to study the transport characteristics of a superlattice. The main problem besides the scattering through optical phonons and lattice imperfections is the injection of the carriers. In a conventional superlattice, embedded between two highly doped contacts, the injection of electrons into the Stark states happens only at high fields, where the states already get localized. We have performed calculations of the bandstructure and the current for GaAs/GaAlAs superlattices with an electric field applied. The superlattices considered have periods of 11 nm and 9 nm with 2.6 nm AlGaAs barriers. Two configurations are investigated: the first one is a two-terminal device with the superlattice between two highly doped n^+-GaAs contacts. The second one is a three-terminal device- experimental results reported in the 2nd. interim report- with a single barrier injector followed by a short basis contact and afterwards the superlattice structure. The basis contact allows to adjust the injection energy and the superlattice bias independently.
The calculation of the bandstructure is done in the envelope function approximation using a transfer-matrix method The current is calculated assuming ballistic transport through the superlattice. The Fermi energy is calculated from the requirement of charge neutrality. The position, the splitting and the change with doping concentration of the donor levels are taken into account. The results for the n^+-n^--n^+-superlattice show a strong temperature dependence. This can easily be explained by occupational effects: as the Fermi energy in the low doped region is below or at most at the GaAs-band edge only the thermal tail of the electronic distribution in the emitter contact can be injected into the superlattice. If the temperature is increased, the Fermi energy in the low doped region remains at the band edge or even drops down for doping concentrations $n^- < 10^{16}$ cm^{-3} but this is compensated by the increased extension of the thermal tail which is $\propto kT$. This effect increases the ballistic current by orders of magnitude if the temperature is raised from 4.2 K to 44.8 K. This results indicates that superlattice transport extends to higher temperatures.

In the three-terminal device the situation is totally different, because one is able to inject electrons into the superlattice at the resonant energies. In this situation the current is mainly resonant. The experimental results for the three terminal device agree within a factor of two with the calculations, which assume ballistic transport through the superlattice structure. This confirms that the superlattices used are of high quality and exhibit ballistic transport through the whole superlattice. In the following period we will investigate the current as a function of the number of periods to obtain the coherence length of the superpattice.

The systematic studies of the electron transport in quantum wires have been continued. Magnetophonon as well as magnetic depopulation experiments are used for a systematic analysis of subband spacings as a function of carrier density. It is found that the subband energy spacings increase systematically with decreasing 1D electron density. The polaron mass in 1D systems, which is also accessible by an analysis of the Magnetophonon effect is found to increase with increasing subband spacing. This effect is due to an enhancement of the electron-LO phonon coupling with decreasing carrier density due to a decreasing screening. These experiments allow an optimisation of quantum wire confinement potentials.
The papers
" Electron Dynamics and Band Structure in High Quality GaAs/AlGaAs Superlattices" by
W. Boxleitner, C. Rauch, G. Strasser, L.H. Hvozdara, E. Gornik, U. Meirav, V. Umansky, H. Shtrikman accepted for publication in Proceedings of the 23rd. Intern. Conf. on the Physics of Semicond.
and
" Transport and Farinfrared Spectroscopy of Quantum Wires" by
E. Gornik, G. Ploner, V. Rosskopf, G. Strasser accepted for publication in Proceedings of the 12th. Intern. Conf. on the Application of High Magnetic fields
will appear in World Scientific Publishing