Photoreflectance probing of a InGaAsP/InP laser structure

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The advantage of photoreflectance (PR) spectroscopy to investigate optoelectronic devices is presented on the example of a standard 1.55 μm InGaAsP/InP based laser structure. The structure was grown by molecular beam epitaxy (MBE) on a InP substrate, and it is composed of a quantum well (QW) placed in a p-i-n junction (InGaAsP layers with different content and doping; 1.15Q p-type/1,24Q/3QW/1.24Q/1.15Q n-type). In order to separate PR signal from different part of the structure different wavelengths of pumping beam were applied, and PR was measured "in-phase" and "out-phase" configurations. In addition for a better interpretation of PR spectra, a modulated transmittance measurement was carried out. Finally, it is shown that the PR technique can probe different parts of the laser structure, and PR spectrum can be fruitfully analysed. We investigate transitions originating from the QW active region of the laser structure and individual layers of the p-i-n junction. In the case of transitions in QW, besides the ground state transition two excited state transitions are visible. In the case of transitions originating from 1.24Q and 1.15Q layers, PR resonance possesses Franz-Keldysh oscillations (FKOs) which are associated with some built-in electric fields in the laser structure. For the 1.15Q layer the built-in electric field is a surface field which exists at the air/1.15Q interface. For 1.24Q layer, which is undoped layer inside p-i-n junction, the FKOs are associated with the junction field. The built-in electric fields are determined by using the Fourier analysis and are compared with the expected electric field, which is estimated from the position of the acceptor and donor energy levels in the p- and n- type materials at each side of the junction. In addition, standard photoluminescence (PL) spectra were measured and compared with results obtained from PR. The comparison of PR (absorption-like) and PL (emission-like) spectra is presented as the basic method to investigate the character of absorption and recombination processes in semiconductor heterostructures.

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