Temperature Dependence of Refractive Indices of $In_{0.53}Ga_{0.47}As$ and InP in the Mid-Infrared Spectra Range Determined by Fourier Transform Spectroscopy

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The main motivation behind the determination of refractive indices of InP and InGaAs in mid-infrared spectral range is to enable more accurate and effective analysis and design of materials and optical components for a variety of applications e. g. growth of active regions for mid-infrared sources of light such as quantum cascade lasers (QCLs) and detectors. QCLs are semiconductor lasers that emit mid-infrared light, and have a wide range of applications in chemical sensing, medical diagnostics, and environmental monitoring [1]. InP substrates provide a suitable platform for the epitaxial growth of QCLs with high output power, high efficiency, and good thermal stability [2]. Moreover, it was shown, that InP and InGaAs can be used to grow efficient Distributed Bragg Reflector (DBR) designed for near-infrared spectral range [3]. By controlling the reflectivity and transmission of infrared light, DBRs can help improve the performance and functionality of infrared devices. In our case we will show that functionality of mentioned concept InGaAs/InP DBR can be further exploited for longer wavelengths i.e. 4 μm.

Refractive index of InP was determined by transmittance measurements of double sided polished undoped substrate in wide spectral range performed for temperatures ranging from 10 K to 300 K and through the analysis of measured interference pattern [4]. The result in near-infrared spectral range was verified by common spectroscopic method for measuring refractive index - ellipsometry, which measures the polarization of light reflected from a sample at various angles of incidence and allow us to adjust the curve for longer wavelength with high accuracy [5]. This knowledge was used to determine the refractive index of $In_{0.53}Ga_{0.47}As$ in the same wide range of temperatures by modelling the experimentally obtained spectra of reflectance measured on $In_{0.53}Ga_{0.47}As$/InP DBR with Lumerical software. The modelling of experimental spectra for 300 K required adjusting the nominal values for layer thicknesses of about 2% which finally made the refractive indices of $In_{0.53}Ga_{0.47}As$ only unknown parameter to generate DBR reflectance spectrum for lower temperatures. This approach provides an accurate and non-destructive means of refractive index determination for semiconductors in wide range of temperatures and broad mid-infrared spectral range.

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