MHCG gratings as active mirrors for surface emitters in mid infrared

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The source of light in the mid-infrared has been successfully applied, inter alia, in imaging and open-air communication, however, the most important motivation behind developing sources of light in this spectral range is optical gas sensing. Currently applied gas sensing systems are based on type-I-quantum-well based diode lasers, Quantum Cascade Lasers – (QCLs), and Interband Cascade Lasers (ICLs), which dominate in the spectral range between 3-5 µm. The proposition is to expand application of QCLs in this spectral range due to it several advantages: easy wavelength tuning across a broad range of mid-infrared, high efficiency due to cascade design and fast switching. To compete with existing solutions, we need to apply VCSEL architecture for QCLs as it has been done for ICLs. This is very challenging due to lack of the light electric field component necessary to induce cascade emission from intersubband transitions, in VCSEL. To overcome this problem, we propose to exchange one of DBR mirrors in VCSEL architecture to monolithic high-contrast refractive index grating (MHCG).

MHCG are sub-wavelength gratings which exhibit strong polarization properties and high reflectance. As was shown in [1] calculations suggest that it is possible to control polarization of light by adjusting grating sizes; therefore, it is possible to induce stimulated emission in QCs. Moreover, application of MHCG instead of DBR reduce significantly thickness of the device. We present experimental results of reflectance and photoluminescence measurement of InP based MHCG and QCLs structures, which shows increase in the signal from QCLs and polarization properties of MHCG. Intersubband character of transition from QCLs sample was verified by pump-probe measurement and comparison of lifetimes of different transitions from investigated sample. Experimental results are supported by calculations applied through the plane-wave reflection transformation method which allow us to estimate appropriate design of the structure.

[1] T. Czyszanowski, *IEEE Photonics Technol. Lett. 30* (2018)

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