Optical Characteristics of Monolithic High-Contrast Gratings for Quantum-Dot Vertical-Cavity Surface-Emitting Lasers at 940 nm.

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Vertical-cavity surface-emitting lasers (VCSELs) have a wide range of unique properties that distinguish them from conventional semiconductor lasers [1]. However, they still face some challenges, for instance, they require innovations in reduction of the thickness of the cavity mirrors which are typically distributed Bragg reflectors (DBRs). Monolithic high-index contrast gratings (MHCGs) are a very attractive alternative for DBRs as well as externally-fabricated high-contrast gratings (HCGs). MHCGs has been already proven as efficient mirrors for VCSELs [2-5]. They bring unprecedented simplification of the device designs and offer flexibility in the material choice, opening new prospects for realization of VCSELs emitting at wavelengths hardly achievable in the past. MHCGs are able to reflect light, as well as can classical subwavelength HCGs, but without the requirement to be sandwiched between low-refractive-index layers [6].

In contrast to standard DBRs, the MHCG enables resonant wavelength setting of every laser in the on-chip array separately, by design of MHCG geometrical parameters. As a result, the MHCG VCSELs array chip can be fabricated in a cost-efficient way on a single wafer, reducing greatly the costs of production and device footprint.

In this work, we characterize optically MHCGs with different geometries by performing microreflectance measurements. Gratings design has been numerically optimized for high reflectivity (> 90%) in the 930-955 nm spectral range required for VCSELs in the optical water vapour detection systems. To achieve this, the grating period, filling factor and trench depth were varied. Three sets of gratings differing in etching depth have been fabricated by means of electron-beam lithography on a double-polished GaAs substrate. Within each set filling factor and trench width was varied to cover theoretically predicted high reflectivity area. The experimental characteristics are compared with numerical results to provide feedback for both fabrication and modelling. Obtained results are an important step in development of QD VCSELs with MHCGs as a top mirror.

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