Fabrication of silicon-integrated telecom-wavelength photonic-crystal surface- emitting lasers using micro-transfer printing

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Photonic-crystal surface-emitting lasers (PCSELs) are attracting significant interest for a range of different applications in materials processing, communication and sensing [1]. As a key attribute, they can produce large-area singlemode emission power using a two-dimensional photonic crystal cavity where in-plane propagating waves are diffracted in the vertical direction. While superior PCSEL performance so far has been achieved using GaAs-based devices with emission in the near-infrared wavelength regime, there is an increasing interest in longer-wavelength InP-based PCSELs for a range of applications, e.g. in fiber-optical telecommunication. This typically requires significantly higher modulation rates than what is available from standard PCSEL designs aiming for large-area devices with high emission power. Smaller-area devices are limited by lateral loss, which can be mitigated using a more advanced grating layer that provide in-plane feedback [2]. However, such grating layers need to include differently sized features which is challenging to realize using epitaxial regrowth, the present standard fabrication method for high-performance PCSELs. Here we report on the development of 1.55-μm hybrid InP/Si PCSELs [3] using an industrial micro-transfer print (MTP) process. In this approach, an InP-based active layer is superimposed upon a pre-patterned silicon substrate. This MTP-based technique enables an arbitrary grating layer geometry, while requiring optimization of the InP-based membrane pre-processing for high-quality layer integrity and interface control.

1. S. Noda et al., IEEE J. Sel. Top. Quantum Electronics, 2017

2. T. Inoue et al., Opt. Express, 2020

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