

Enhancement of VCSEL performances with a new bonding process

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A novel bonding method, to report a III-V active region on a Si host substrate through the use of BCB polymer bonding and Cu μ -heat sinks, is presented. This technique, named Through Silicon Holes Electroplated Copper (TSHEC) process, has been validated in the case of quantum wells-based optically-pumped vertical-cavity surface-emitting lasers (OP-VCSELs), where a single mode emission power exceeding 2mW at 20°C has been obtained for a device integrating bottom hybrid Bragg mirrors of 20 μ m of diameter.

The development of power efficient vertical-cavity surface-emitting lasers (VCSELs) in the 1.55 μ m range, with relatively high output power (>1mW) and enhanced thermal dissipation is still challenging, but would represent a real breakthrough for the scientific community, with important perspectives in different areas of fundamental research and applied physics (WDM and FTTH networks, gas sensing and deformation detectors, biomedical, microwaves, etc.) [1-2]. In this context, a novel bonding technique is presented in this work. It relies on the use of a BCB polymer bonding to virtually report any material on a Si host platform, through the use of Cu-filled vias acting as μ -heat sinks. This so-called Through Silicon Holes Electroplated Copper (TSHEC) technique [3] has undoubtedly several advantages, since it allows a hybrid integration of III-V active regions on a Si substrate (for photonic, microelectronic, microfluidic integration), it avoids stress-induced limitation with respect of standard large Cu surface solutions, and it is cost-effective. This approach has been recently validated in the case of InP-based OP-VCSEL structures (cf. Fig. 1a), for which an output power exceeding 2mW with a threshold as low as 7mW at 20°C has been demonstrated, in the case of a bottom hybrid metal-dielectric Bragg mirror (H-DBR) of 20 μ m in diameter. Different diameter sizes for the bottom H-DBR have been tested, ranging from 20 μ m up to 100 μ m. According to the size of the H-DBR, different values for the output power have been measured, together with a red shift of the laser emission (cf. Fig. 1b), which are related to different values for the thermal impedance of the devices [4].

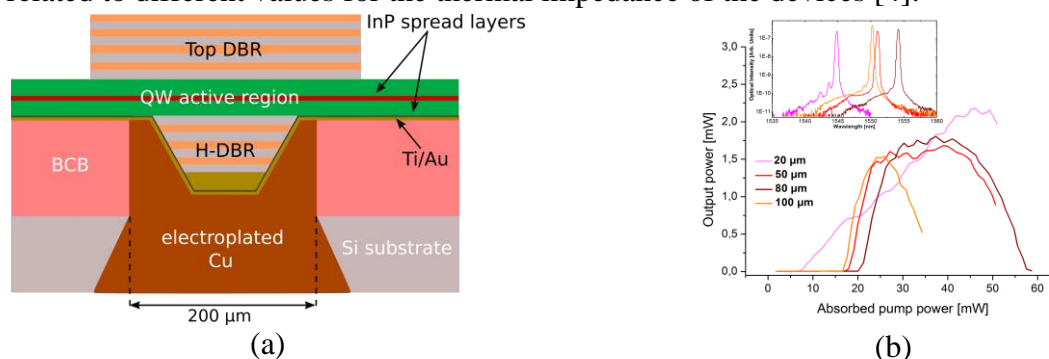


Figure 1: (a) Schematic view of the OP-VCSEL realized with the TSHEC process. (b) PI emission characteristics of the OP-VCSELs with different bottom H-DBR diameter sizes (lasing spectra are in inset).

[1] D. Ellafi et al., Opt. Express, 22, 32180-32187 (2014)

[2] S. Paul et al., IEEE J. Sel. Top. Quantum Electron., 21, 436-443 (2015)

[3] F. Taleb et al., 26th IPRM International Conference, Montpellier (2014)

[4] F. Taleb, S. Pes et al., to be submitted to IEEE Photon. Technol. Lett.