Multi-oxide Layer Vertical-Cavity Surface-Emitting Lasers with Improved Modulation Bandwidth

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Abstract — We demonstrated VCSELs with multi-oxide layers (MOX) to reduce parasitic capacitance for high speed modulation beyond 10 GHz. We achieved a small signal modulation bandwidth of 11 GHz while that of a conventional single oxide layer VCSEL is 7 GHz.

High speed vertical-cavity surface-emitting lasers (VCSELs) with a modulation bandwidth of greater than 10 GHz is expected to be a key device in ultrahigh-speed optical data links. So far, the record high speed operation of VCSELs reaches a small signal modulation bandwidth of 21.5 GHz [1]. The practical modulation bandwidth of VCSELs is limited by their parasitic capacitance. A novel AlAs multi-oxide layer structure (MOX VCSEL) was proposed for reducing the parasitic capacitance [2]. In this paper, we demonstrated a GaInAs/GaAs MOX VCSEL, exhibiting a higher modulation bandwidth of 11 GHz than that of a conventional VCSEL with a single oxide layer.

Figure 1 shows the schematic structure of a fabricated top-emitting GaInAs/GaAs MOX VCSEL. Four multi-oxide layers with a thickness of quarter wavelength were formed in the top p-type GaAlAs/GaAs distributed Bragg reflector (DBR) in addition with a 30 nm thick oxide confinement layer. Oxide current confinement and MOX structures were formed at the same time by mesa etching followed by wet selective oxidation.

Small signal frequency response was measured by using a 20-GHz bandwidth network analyzer and a 25-GHz bandwidth PIN-FET receiver, which are shown in Fig. 2. A 3dB bandwidth of the MOX VCSEL was 11 GHz, which is 60% higher than the 3dB bandwidth (7 GHz) of the VCSEL without MOX. This improvement in a modulation bandwidth may result from the reduction of parasitic capacitance in the thin oxidation layer. A parasitic roll-off (3dB) frequency was estimated to be 16 GHz. We expect further improvements in the modulation bandwidth by optimizing the number of MOX layers and by avoiding other contribution of parasitic capacitance. In addition, higher power single mode operations are also helpful for increasing the overall modulation bandwidth.

Reference