Vertical Cavity Surface Emitting Laser with photo-aligned liquid crystal overlay

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VCSELs (Vertical Cavity Surface Emitting Lasers) have been used in optoelectronic devices in the past decade in optical interconnects that demand high bandwidth and low power consumption [1-4]. Combining this type of laser with a material with a high electro-optic coefficient such as liquid crystals could add extra functionality to the VCSEL such as polarization control and wavelength tunability which is interesting for applications in sensing and reconfigurable optical interconnects. In this work [5], we fabricate and characterize electrically driven VCSEL cells, in which the emitting area is covered with a thin extra-cavity LC layer that can be driven separately. The LC layer affects strongly the polarization state of the VCSEL emission due to its birefringent properties.

A VCSEL chip of 250 µm × 250 µm dimension with 850nm emission wavelength is placed inside a liquid crystal (LC) cell and covered with a thin layer of aligned LC using photo-alignment technology. The top and bottom glass substrates are covered with respectively a patterned and uniform transparent conductor (ITO). The top ITO layer is patterned by using lithography in order to define a contact for the VCSEL anode and another contact for applying a voltage over the LC layer. The gap between the left and right ITO layer is 4 µm. A thin azo dye SD1 layer is spin coated on the top substrate which acts as a photo-alignment layer for the LC [6]. The cathode and anode of VCSEL are electrically connected to the bottom and top ITO electrodes, respectively, through micro-sized gold coated silica embedded in UV cured optical glue. The thickness of the LC layer is determined by the size of these conductive spacers.

The light emitting properties of VCSEL are investigated, including the optical power and the polarization state, all in function of the applied current to the VCSEL and the voltage applied across the LC layer. Before LC is filled in the cell, the VCSEL emission is practically completely elliptically polarized, with a ratio of 14.3 between the powers along the long and short axis. After LC is filled in, the polarization state of the laser beam can be controlled by the voltages applied over the LC layer. This technology opens an effective way to fabricate integrated VCSEL chips in optoelectronic devices.

References:

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