

Mapping of mechanical strain by DOP of oxide-confined GaAs based VCSEL operating at 850 nm

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Remarkable progress made in VCSELs has led them to meet an increasing number of applications, among them, high speed data communications at 850 nm, in data centers [1]. In this context, these laser diodes are subject to very stringent performance and reliability requirements. These requirements have direct consequences on the design, processing, and geometry of the semiconductor laser diode, and on its operating parameters. Today, electrical and optical confinement is achieved by selective wet oxidation of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ ($x > 0.94$) layers within the VCSEL's vertical structure [2-3]. Except for the MQWs, these aluminum oxide (AlOx) regions constitute the main source of concentrated internal mechanical stress and these associated deformations are critical since they are located close to the active area of the VCSEL [4-5]. Degradation mechanisms have been observed as extended dislocations originating from highly stressed areas pointing to the active region [6]. Much work has been carried out using different non-destructive strain measurements on AlOx confined structures [7-9].

In this work, we report an optical investigation of the strain distribution in VCSEL mesa structures using degree of polarization (DOP) of photoluminescence (PL) measurements at room temperature. We correlate the DOP of the PL to the spatial distribution of the embedded anisotropic strain in a VCSEL structure. Analysis of the DOP has been shown to be a useful technique for mapping the internal strain field due to device-processing in GaAs-based materials [10-11]. We performed measurements normal to the surface of the sample on different rectangular mesa dimensions focusing on the oxidation process. We studied the effect of the epitaxial design, the oxidation process conditions (temperature, annealing) and the size of the unoxidized aperture on the main components of mechanical stress inside the structure. These measurements allow non-destructive evaluations of the mechanical stresses accumulated in VCSEL devices during their manufacturing process.

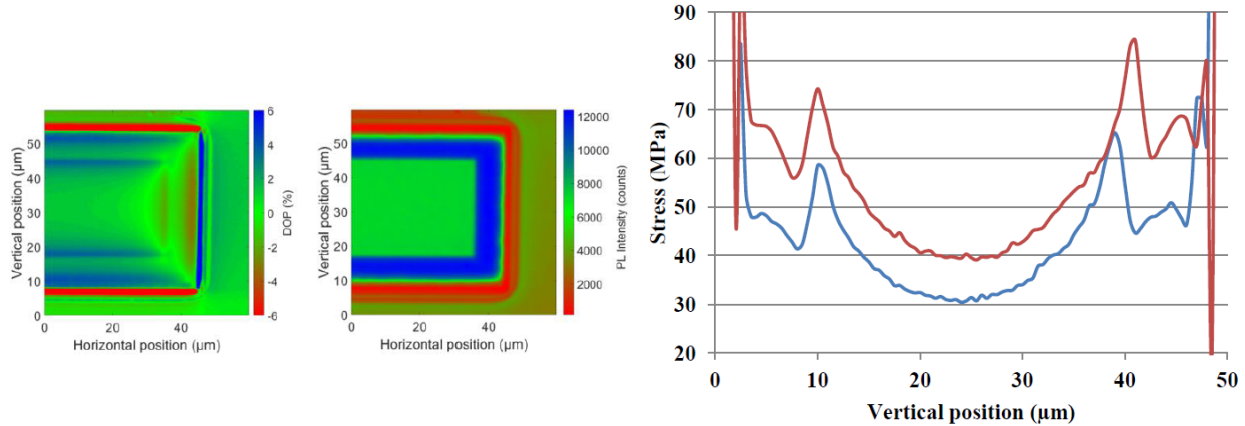


Fig. Left: color scale maps of the DOP (left) and PL (right) yield from the surface for a rectangular (50 μm x 1 mm) oxidized VCSEL structure. **Right:** associated stress profiles along the vertical axis of two rectangular structures without annealing (red) and annealed (blue) right after the oxidation process.

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