PROJECT FINAL REPORT EXECUTIVE SUMMARY

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Project acronym: **DELIGHT**

Project title: **Development of low-cost technologies for the fabrication of high-performance telecommunication lasers**

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Executive summary

The DeLight project was aimed at developing low-cost high-performance telecommunication lasers by employing advanced laser structures and fabrication technologies. Three critical elements were addressed in terms of reducing the fabrication cost of the lasers:

- the difficulty and complexity of the fabrication;
- the cost of equipment ownership and the fabrication process throughput;
- the fabrication yield and the controllability of the device characteristics.

Laterally-coupled (or laterally-corrugated) ridge waveguide (LC-RWG) surface gratings, illustrated in Fig. 1a and 1b, have been developed to avoid the problematic overgrowth employed in the fabrication of conventional buried gratings, thus reducing the fabrication difficulty and complexity. The cost of equipment ownership and the fabrication throughput were addressed by employing UV nanoimprint lithography for imprinting the fabrication process masks. Etched end facets, fabricated in conjunction with the LC-RWG surface gratings (Fig. 1b), have been developed and tested for improving the fabrication yield and the device performances, which are largely influenced by the uncontrollable positions of the cleaved end facets.

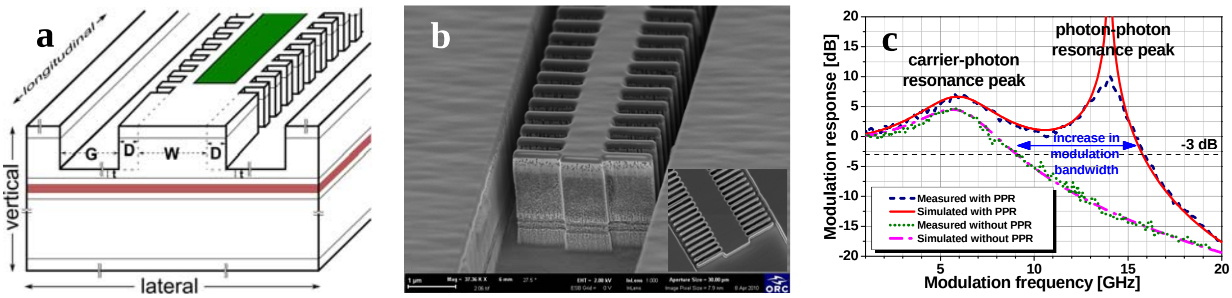

Fig. 0-1: a) Sketch of the laterally-coupled ridge-waveguide (LC-RWG) grating structure; b) SEM images of the etched facet of a laser with LC-RWG gratings; c) measured and simulated small-signal modulation responses from DFB lasers with and without PPR.

In terms of improving the performances of telecommunication lasers the main target was on increasing the laser direct modulation bandwidth. It should be noted that, despite considerable research efforts, the direct laser modulation bandwidth has improved much less than the other laser characteristics. This is mainly because it has conventionally been linked to the carrier-photon resonance (CPR), which has inherent physical limitations. Consequently, DeLight did not target the increase in direct modulation bandwidth by increasing the CPR but by introducing a supplementary high-frequency photon-photon resonance (PPR). Fig. 1c shows the simulated and measured small-signal modulation responses for two types of lasers with different longitudinal structures, which were fabricated in the same fabrication run from the same ‘legacy’ epiwafer (intended for the fabrication of Fabry-Perot lasers at 1.55 µm). The figure illustrates the increase in direct amplitude-modulation bandwidth by comparing the modulation response of a single-section distributed feedback (DFB) laser that does not have PPR with the modulation response of a multi-section laser with the PPR properly placed with respect to the CPR.

Multi-section lasers employing LC-RWG surface gratings and operating at 1.3 and 1.55 µm have been designed, fabricated (mainly from legacy epiwafers, intended for Fabry-Perot lasers) and characterized. Photon-photon resonances, largely determined by the longitudinal structure of the lasers and adjustable by bias, were achieved consistently and systematically, according to the model and simulations. The project was successful in developing the LC-RWG surface gratings combined with a UV-NIL-based cost-effective fabrication process and a new concept for extending the direct laser modulation bandwidth by exploiting the PPR. However, due to the combined complexity of the technical problems to be solved, in particular due to the difficulty of achieving a relatively smooth and controllable small-signal modulation response between the CPR and the PPR (mainly when those are spaced far apart), the project fell short of achieving its final quantitative goal: a low-cost direct modulated laser capable of 43 Gbit/s. However, the results obtained by DeLight prove that there is a definite possibility for fabricating low-cost high-performance telecommunication lasers by exploiting LC-RWG surface gratings, nanoimprint lithography and the photon-photon resonance.