Quantum-Dot InAs/InGaAsP/InP (100) Twin-Stripe Lasers for Secure Encrypted Communication

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Abstract: Quantum-dot twin-stripe lasers have been fabricated and characterized. Dynamic features have been observed indicating regimes of chaotic operation that make these lasers suitable for chaotic-encryption application.

1. Introduction
Non-linear dynamics in Quantum Dot (QD) lasers have attracted the attention of the research community for over a decade. These interesting non-linear dynamic features can not be only studied in detail but also exploited. Encryption schemes for hiding messages in chaotic signals have also attracted attention to a great extent in order to transmit information securely. But to date these encryption systems have had two major issues: (1) although chaos on a laser chip already has been proven experimentally [1], the fabrication of reproducible chaotic lasers is still a major issue; (2) also, traditionally, optical chaos has been created by externally influencing a laser in complicated set-ups making difficult the use of the system for commercial applications. Our approach is to simplify the system and increase its reproducibility by producing the chaos 'on chip', without adding extra components to the set-up. For that purpose, we use twin-stripe lasers.

2. Device details
By using InAs/InGaAsP/InP (100) QD material [2] operating at 1.5 µm to fabricate devices consisting of two laterally coupled non-linear oscillators, or twin-stripe lasers, we have the advantage, due to the zero dimensional confinement of the QDs, of achieving evanescent coupling between the stripes with no lateral carrier diffusion through the active region. In this material, lateral carrier diffusion, through thermal carrier excitation to the wetting layer or the barriers, takes place over up to 100 nm. A SEM image of the resulting device can be observed in Figure 1. The resulting devices are 4 mm long with two ridge waveguides with a width of 2 µm each, separated by 2.5 µm. The fabricated lasers have then been characterized showing good performance with a threshold current of 200 mA in each stripe at 285 K and an output power of up to 8 dBm per stripe and per facet.

3. Dynamic characterization
The dynamics of the lasers are influenced by the evanescent coupling between the stripes, and changing parameters such as the separation between the stripes in the fabrication process, or of the bias current in each of the stripes, transitions to chaos similar to those found in single-stripe lasers subject to external influences have been observed [1, 3]. For example, in Figure 2 the r-f spectra of the output of two of the stripes have been plotted as a function of the bias current on its neighbor stripe (I_neigh). In that figure, marked with a dashed line, there is a region with unpredictable dynamical behavior. We used the points of operation contained in that region for the synchronization of a master and slave laser which can work as emitter and receiver of an encrypted communication link.

4. References