

Shot-Noise-Limited Operation of Electrically-Pumped Quantum Wells-Based VECSEL Emitting at Telecom Wavelength

Anwar KERCHAOU,^{*1} Alexandru MEREUTA,² Andrei CALIMAN,³ Steve BOUHIER,¹ Thomas BATTE,¹ Cyril HAMEL,¹ Cyril PARANTHOEN,¹ Christophe LEVALLOIS,¹ Alain LE CORRE,¹ Eli KAPON,² and Mehdi ALOUINI.¹

¹ Institut Foton, Univ Rennes 1, INSA, CNRS – UMR 6082, F-35000, Rennes, France

² Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland

³ LakeDiamond SA, Rue Galilée 7, 1400 Yverdon-les-Bains, Switzerland

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An efficient method to reduce to the shot noise level the intensity noise of a semiconductor laser, is to make it oscillate in the so-called class A regime where the relaxation oscillations disappear. In Vertical-External-Cavity Surface-Emitting Lasers this class A regime is easily reached since the cavity photon lifetime can easily exceed the population inversion lifetime. At telecom wavelengths in particular, such approach has been successfully implemented in order to generate an optically carried high spectral purity microwave signal [1]. Moreover, it has been shown that replacing the quantum well active medium by a quantum dash active medium can lead to similar shot-noise limited class A operation in addition to robust polarization oscillation [2]. All these demonstrations relied on optical pumping of the gain structure. Thus, tailoring such approach to electrically pumped structures might pave the way to its implementation in real systems where compactness and low power consumption are mandatory. The main constraint in realizing such a laser is the achievement of significant and uniform population inversion on a large area. We present here what is to our best knowledge the first electrically pumped class A shot-noise limited laser emitting at telecom wavelength.

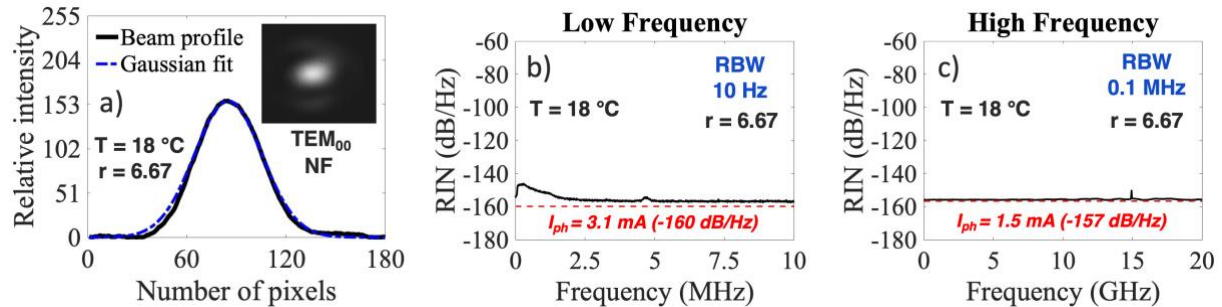


Fig. 1: a) Near field mode profile. b) and c) Low and high frequency RIN. NF: near-field, r: pumping rate, RBW: resolution bandwidth. Red dash line: expected relative shot noise level.

The active medium consists of a quantum well structure grown on InP substrate that is integrated in a high-Q external cavity. A careful design of the electrode clear aperture (20 μm diameter), optimization of the output coupler ($T = 0.5\%$, $R_{cc} = 1 \text{ cm}$), and adjustment of the cavity length enabled us to get at the same time single transverse and longitudinal mode oscillation without any intracavity etalon, while ensuring class A operation. In these conditions the emitted optical power is 3 mW for 60 mA current, that is, 120 mW electrical power. The acquired relative intensity noise spectra exhibit shot-noise limited operation on an extremely wide spectral region, i.e., from 2 MHz up to 20 GHz. Accordingly, the measured relative intensity noise depends only on the measured photocurrent. Hence, it is found to be -160 dB/Hz at low frequency for 3.1 mA available photocurrent and -157 dB/Hz at high frequency for 1.5 mA available photocurrent.

We are currently investigating possible increase of the output power as well as simultaneous oscillation of two orthogonal polarizations for dual frequency operation of such a laser.

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