Two photon excitation imaging used to investigate photonic quantum ring lasers

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Photonic quantum ring (PQR) lasers [1] are a novel type of semiconductor lasers with a structure similar to vertical-cavity surface-emitting lasers (VCSELs), that exhibit a two threshold-behaviour of successive lasings. The first is the PQR behaviour that occurs at µA threshold currents with the structure lasing on its circumference and the second is the usual VCSEL mode at threshold currents in the range of mA.

In a PQR laser, photons generated in the active region are near-perfectly vertically confined by the top and bottom distributed Bragg reflectors. There is also an in-plane annular confinement generated by total internal reflection along the lateral boundaries of the active disk. The 3D confinement of photons generates a Rayleigh toroid effectively formed along the circumferential region of the active area and defined by the Rayleigh’s bandwidth [2]:

\[ W_{Rayleigh} = R(1 - n_{eff}/n) \]  \hspace{1cm} (1)

We report here on the properties of the two-photon excited photoluminescence (TPEP) of GaAs/AlGaAs PQR laser structures. The experiments presented deal with the analysis of both the spectral and the spatial properties of the emission. TPEP. For this purpose the maximum emission wavelength and the TPEP dependence with the excitation wavelength (Fig. 1) and power are investigated. The spatial distribution of the emission is also analyzed.

We also propose a new estimation method for the Rayleigh’s bandwidth, using the full width at half maximum of the lateral profile of the PQR laser emission.

The results are important as TPEP proves an useful method for investigations on PQR lasers and may help understanding the photon confinement in such devices.