An electrically driven polariton laser

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Abstract: Polariton lasing under electrical pumping is observed in a GaAs multi-quantum-well microcavity diode. Lasing in the strong-coupling regime is unambiguously evidenced by detection of Zeeman-split emission in an external magnetic field as a result of the polaritons' excitonic content.

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1. Introduction

While conventional lasers are based on stimulated emission which requires a certain amount of power for population inversion, a new type of coherent light source named polariton laser uses stimulated scattering into one energy state, from which polaritons decay spontaneously with radiation features similar to that of a conventional photonic laser source. Polaritons are formed in quantum well (QW) microcavities as the consequence of strong exciton-photon coupling. Above a critical particle density, the bosonic polariton gas can undergo a condensation process [1, 2]. This promises a more energy-efficient laser operation in terms of lower threshold powers. In this work, a polariton laser under electrical pumping is presented [3], for which strong light-matter coupling is unambiguously evidenced due to a Zeeman-splitting of the laser mode when an external magnetic field is applied [4]. This provides access to a practical use of polaritonic light sources for future opto-electronic applications.

2. Experimental results

Electroluminescence from a four InGaAs QW microcavity (p-i-n) diode based on 20-µm micropillars etched into the cavity wafer is measured via far-field resolved spectroscopy. The structure consists of doped AlAs/GaAs distributed Bragg reflectors (DBRs) and an intrinsic cavity, allowing for current injection. Current-density-dependent investigations of the diodes reveal a two threshold behavior, with energy-momentum dispersions showing three emission regimes. These are attributed to low-density lower-energy-branch polariton emission, polariton lasing and cavity mediated photon lasing in the weak-coupling regime. A spin-split polariton ground-state emission is observed in polarization-resolved spectroscopy up to a current density corresponding to the photon-lasing threshold under the presence of an external magnetic field. At 5 T, the dependency of the detected Zeeman-splitting on the current density demonstrates a clear transition from strong coupling above a first threshold towards a weakly coupled cavity mode, providing clear proof of polariton laser operation between the two observed thresholds.

References

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