A New Generation of Electrically Driven Polariton Devices

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Owing to their composite light-matter nature, polaritons exhibit strong nonlinearities and their behavior is often governed by a distinctive bosonic character, which is responsible for a series of spectacular demonstrations such as stimulated scattering of polaritons, condensation, superfluidity and polariton lasing. From a device point of view, a particularly attractive feature of polaritons and of their use in lasers is the two orders of magnitude reduction of threshold carrier density compared to conventional semiconductor lasers demonstrated in optical experiments.

Essential prerequisites to achieve a real-world electrically pumped polariton laser are to combine in the same MC device, i) persistence of strong coupling under electrical injection up to room temperature, ii) efficient population of \(k_\parallel \sim 0\) polariton states at the bottom of the trap, bypassing relaxation bottleneck effects. Here, we report experimental realization of a room temperature GaAs polariton LED (Fig.1), which directly emits from polariton states[1,2]. The strong coupling regime is evidenced by the characteristic anticrossing observed in temperature and angle-resolved EL measurements. We also show that by increasing microcavity finesse it is possible to enhance polariton relaxation on the lower branch and achieve ultralow polariton lasing threshold under nonresonant optical excitation up to a temperature of 50K opening the way to the future realization of an electrically pumped polariton laser.

![Fig. 1: RT Polariton LED device](image1)

![Fig. 2: Polariton lasing under nonresonant optical pumping](image2)

Finally, we demonstrate a new technique for manipulating polariton interactions, by incorporating electronic tunneling in the active region of the microcavity diode. Tunnelling of electrons is played off against exciton light coupling to control the polariton amplification process on \(ps\) timescales. This scheme allows direct control of parametric scattering efficiently (> 90% for \(V=100 \, mV\) applied bias), and can be used in a variety of ultra-high speed modulation schemes.

These results strongly suggest that the GaAs system is well suited for polaritronics applications, given the maturity of GaAs based technologies. Clearly, the whole field of polaritronics could see unprecedented development should this technology become available.