

## *Lasing from a single and coupled double polariton microcavities made of tellurides and selenides*

### ABSTRACT

Lasing relies on the non-linear amplification of light in the active medium of an optical resonator. The tasks carried out as part of the doctoral dissertation focus on the effects of lasing from semiconductor polariton microcavities made of II-VI compounds of the periodic table of elements. The strong coupling of the photon and the electron-hole pair leads to the formation of a double-nature quasiparticle, called the exciton-polariton. The semiconductor microcavities based on materials from the II-VI groups remain much less explored compared to their counterparts from the III-V groups. Due to the greater strength of the exciton oscillator II-VI in semiconductor compounds, their use as an active material opens up a number of new possibilities for optoelectronics applications.

In general, we can observe three laser regimes in the emission from a quantum well coupled to a semiconductor optical microcavity. Polariton lasing in a strong light-matter coupling regime results from the stimulated scattering of exciton-polaritons to the ground state. In the case of higher excitation power, when the strong coupling is lost due to decoherence effects, it is possible to obtain photon lasing for which two mechanisms may be responsible: stimulated exciton recombination or, in the extreme case of a high density of excitation power, stimulated electron recombination of electron-hole plasma. So far, regardless of the selected materials, at most, one or two of the listed regimes have been observed for one structure. Thanks to the appropriate selection of materials and thoughtful design of the microcavity structure, the research carried out as part of the doctoral dissertation showed the presence of all three laser regimes for one structure. It was confirmed by observing the three laser thresholds in the emission from photonic traps in an optical microcavity based on selenides and tellurides with a single quantum CdSe/(Cd,Mg)Se well. This allowed establishing a previously undetermined relationship between three different laser regimes.

Polariton lasing study has also been extended to a system of two coupled

semiconductor optical microcavities with quantum wells based on tellurium compounds. Light-matter coupling in this type of system leads to a four-level polariton system. Bose-Einstein condensation and polariton lasing from the two lowest polariton branches were observed. Spectroscopic measurements with temporal resolution revealed the complex dynamics of the processes responsible for the excitation transfer between the reservoir of light-created carriers and the polariton levels. In particular, it has been shown that the emitting polariton condensates do not coexist in time. The construction of the condensate population on the upper polariton branch follows the radiation decay of condensate that has been produced on the lower branch. Moreover, the presence of condensate on the higher polariton branch is accompanied by the energy-degenerate scattering of exciton-polaritons into the lower energetic polariton branch. Systematic measurements for the double microcavity and theoretical modelling made it possible to understand and describe the mechanism responsible for the condensate dynamics in this multi-level polariton system.

The implementation of the tasks presented in this thesis is essential from the point of view of the usefulness of the materials of the II-VI group in the study of the influence of microstructure on the location and lasing from semiconductor microcavities and in practical applications, e.g. for the construction of polaritronic devices.