MBE growth and nonlinear optical properties of the transmissive microcavity with a single CdTe quantum well

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Exciton polaritons are quasiparticles that arise from the coupling between excitons and photons. To achieve strong light-matter interactions, excitons can be confined within quantum wells, while the concentration of photons can be enhanced by positioning the quantum well between Bragg mirrors, thereby forming a microcavity. The nonlinear response of a single quantum well within such a microcavity holds significant potential for various applications, including its use in artificial neural networks or filtering light pulses depending on a number of photon in a pulse. The primary objective of this study is to develop a transmissive sample consisting of a single quantum well embedded in a microcavity composed of II-VI materials, exhibiting visible nonlinearity.

Molecular Beam Epitaxy (MBE) was used to grow the structure on a 3” GaAs substrate and GaAs buffer. After transfer to II-VI chamber, we have grown a set of II-VI buffers: ZnSe, ZnTe, (Cd,Zn)Te, sacrificial buffer layer of MgTe, and finally microcavity. Upon exposure to water, the sacrificial layer undergoes oxidation and decomposition, enabling the exfoliation of the microcavity onto a sapphire substrate [1,2]. The microcavity is composed of distributed Bragg reflector with 30 pairs of (Cd,Zn,Mn)Te and (Cd,Mg)Te. Inside, there is only one CdTe 10 nm thick quantum well.

Magnesium is a critical component in the DBR due to its ability to significantly reduce the absorption within the microcavity and to reduce refractive index of one layer in DBR pair. However, magnesium is also prone to oxidation, which may compromise the integrity of the DBR. To evaluate the impact of the exfoliation process on the microcavity structure, reflectivity measurements were conducted both before and after exfoliation. The results indicate that, at low magnesium concentrations, the exfoliation process does not adversely affect the quality of the microcavity.

The exfoliated microcavity was further analyzed using photoluminescence at low temperatures, reflectivity, and transmission measurements at both room and low temperatures. In the white-light reflectance map, both polariton modes were present despite the system containing only a single quantum well. Laser transmission power measurements revealed the emergence of bistability for excitation energies below the lower polariton. The shape of the hysteresis curve, along with the white-light reflectance data, suggests a loss of strong coupling at higher excitation power levels.

References

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