Tamm plasmons and exciton polaritons in hybride microcavities

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Motivation

Strong light-matter coupling in microcavities (MCs)
Utilization of generated polaritons for new class of optoelectronic devices

Tamm plasmons on MC structures
• Modulation of polariton energy
• Electrically tunable polariton devices

II-VI materials
Large exciton binding energies
High oscillator strengths $f$

Strong coupling achieved in ZnSe-based microcavities
→ at 4 K with only three QWs – Rabi energy $\Omega_{\text{Rabi}} = 19$ meV
→ up to 220 K with 15 QWs
→ polaronic lasing in micropillars

Tamm plasmons and exciton polaritons

Bragg-polariton sample design

Sample setup

Calculated E-field distribution

Sample setup: thickness gradient of top DBR layer etched by CAIBE

Bragg-polariton sample design

Spectra vertically shifted

Strong coupling at low T
$\hbar \omega_{\text{TM}} = 36$ meV at 300 K

Total splitting LP – UP: 50 meV
→ increase by a factor of 1.7

Reflectivity of sample without and with Ag-layer for different top layer thicknesses

Reflectivity minimum due to Tamm plasmons

Spectral shift of the Bragg polaritons with change of the top layer thickness

Four resonances are observed due to the coupling of cavity, $\hbar \omega_{\text{cav}}$, X$_{\text{hh}}$, and TP resonances

Metal layers supporting Tamm plasmons show strong influence on cavity resonance
→ Tunability of cavity and TM resonance is realized

Advantage of unfolded microcavity:
• Electronic field distribution is calculated for the 1st Bragg mode (BM)
• QWs are located at the field maximum of the BM
• Light-matter interaction between QWs and BM

Strong coupling in unfolded cavity with eight times three ZnSe quantum wells

Strong coupling achieved in ZnSe-based microcavities

Two anticrossings of the cavity mode with X$_{\text{hh}}$ and X$_{\text{lh}}$

Clear signature of strong coupling regime

Two anticrossings of the cavity mode with X$_{\text{hh}}$ and X$_{\text{lh}}$

Total splitting LP – UP: 29.5 meV
→ No strong coupling at RT

Reflectivity of sample without and with Ag-layer for different top layer thicknesses

Anticrossing observed by temperature dependent detuning

At X$_{\text{hh}}$/BM crossing point
$\hbar \omega_{\text{x}} = (32 \pm 1)$ meV, $\hbar \omega_{\text{cav}} = (13 \pm 1)$ meV

Strong coupling regime up to 200 K

Sample setup: thickness gradient of the top layer etched by CAIBE

15 nm of Ag are deposited

Angle resolved reflectivity and PL of Bragg polaritons modified by 18 nm reduced top layer thickness or 15 nm deposited Ag – pronounced spectral shift
→ possible realization of lateral potential traps for Bragg polaritons

Tunable Bragg polaritons in hybrid structure

Influence of Ag-layer - Hybrid state of TP exciton-polariton

Measured results are in excellent agreement with a four-coupled-oscillators model calculation

Summary

Metal layers supporting Tamm plasmons show strong influence on cavity resonance
→ Tunability of cavity and TM resonance is realized

Strong coupling achieved with a simple sample configuration using TP and excitons
→ Promising for electrically tunable polariton devices
• Strong coupling in unfolded cavity with eight times three ZnSe quantum wells
• Coupling of Bragg mode with X$_{\text{hh}}$ and X$_{\text{lh}}$ results in three polariton branches
• Anticrossing was observed under temperature- and layer-thickness variation
• Experimental findings coincide with theoretical calculations
• Strong coupling can be traced up to 200 K
→ ZnSe-based Bragg polariton samples are promising to realize strong coupling near room temperature with a rather simple sample configuration

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