InAs/AlSb structures for giant Rabi splitting of intersubband polaritons

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The optical response of the intersubband excitation of multiple InAs/AlSb quantum wells embedded in a planar semiconductor microcavities has been studied through angle-dependant reflectance measurement. Strong coupling is demonstrated between the intersubband optical transition and the cavity photon. A giant vacuum-Rabi splitting (∼33 meV) was observed both at liquid Helium and room temperature for transition energies of 123 meV and 83 meV. The observed ratios are record-high values for any strongly-coupled systems, and demonstrates the huge potential of this material system for the achievement of the ultrastrong coupling regime predicted theoretically.

Cavity Electrodynamic

- weak coupling: enhancement/inhibition of spontaneous emission
- strong coupling: vacuum-field Rabi splitting, “cavity-polaritons”

Intersubband Cavity Polariton

Intersubband transitions:
- tailorable properties
- 2D electronic transitions are “atom-like”
- ultra-fast radiative relaxation times (~1 ps)

Important parameters: Rabi splitting : \( \Omega \sim \sqrt{\Omega_{\text{wire}}N_{\text{QW}}N_{\text{2D}}} \)

Intersubband resonator:
- 10 QW active region.
- n-doped InAs cladding layer (N~10^{10} cm^{-2}).
- Undoped InAs substrate (N~3.10^{10} cm^{-2}).

Perspectives

Quantum cascade intersubband polariton light emitter

- Resonant tuneling injection to level e2
- Optical cavity resonant with e0-e1 transition

Polaritons with excited subband transitions

- Significative enhancement of the oscillator strength.

Results

\( \lambda = 10 \mu m \)

- Clear anticrossing behaviour both at RT and at 4 K
- Rabi splitting of 33 meV : \( \Omega/\omega \sim 13\% \)

\( \lambda = 15 \mu m \)

- Rabi splitting of 28 meV : \( \Omega/\omega \sim 17\% \)

InAs/AlSb material system

InAs: Low effective mass
- Enhanced oscillator strength.

InAs is a good candidate to reach ultra-strong coupling regime.

Conclusion

- Observation of intersubband polaritons in InAs/AlSb heterostructures inside plasmon-enhanced cavity.
- Realization of giant vacuum-Rabi splitting of 33 meV and high \( \Omega/\omega \) ratio of 17%.
- No evidence of Ultra-strong coupling regime.