InAs/AlSb structures for giant Rabi splitting of intersubband polaritons

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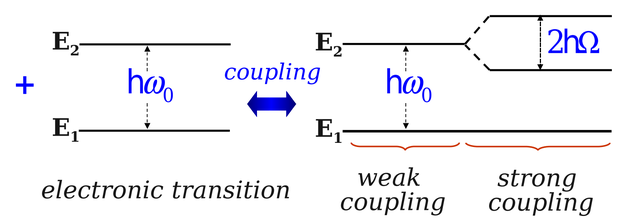
The optical response of the intersubband excitation of multiple InAs/AlSb quantum wells embedded in a planar semiconductor microcavities has been studied through angle-dependant reflectance measurement. Strong coupling is demonstrated between the intersubband optical transition and the cavity photon. 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 Electrodynamics

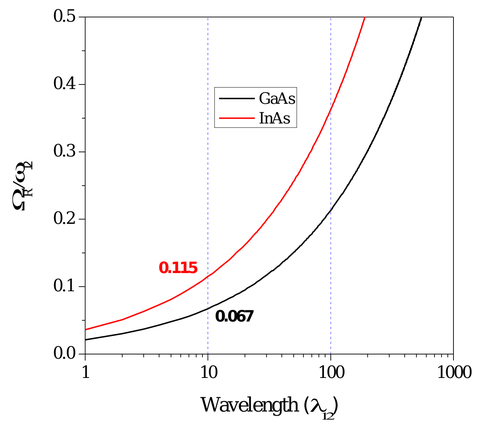
- weak coupling - enhancement/inhibition of spontaneous emission
- strong coupling - vacuum-field Rabi splitting, “cavity-polaritons”



InAs/AlSb material system

InAs : Low effective mass

- Enhanced oscillator strength.

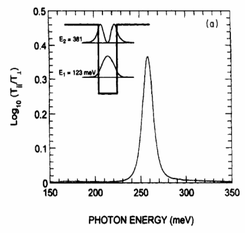


InAs is a good candidate to reach ultra-strong coupling regime.

Intersubband Cavity Polariton

Intersubband transitions:

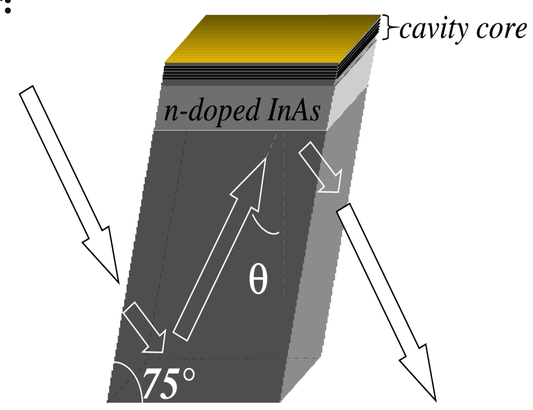
- tailorable properties
- 2D electronic transitions are “atom-like”
- ultra-fast radiative relaxation times (~1 ps)



Important parameters: Rabi splitting : $\Omega \sim \sqrt{f_{osc} N_{QW} N_{2deg}}$

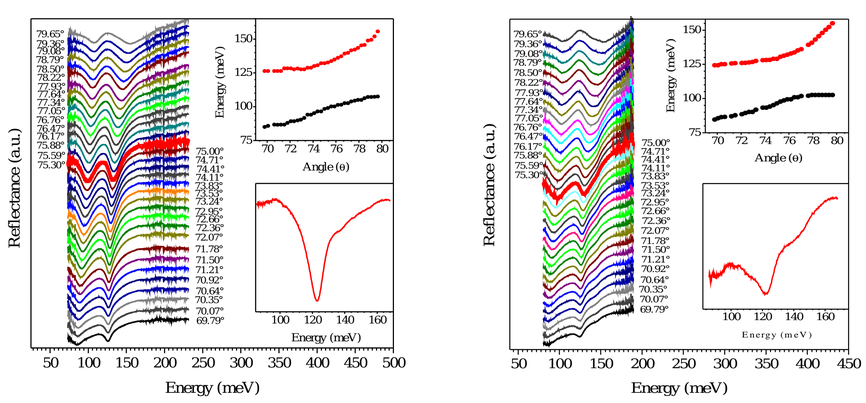
Intersubband resonator:

- 10 QW active region.
- n-doped InAs cladding layer (N~10^{18} cm^{-3}).
- Undoped InAs substrate (N~3.10^{16} cm^{-3}).



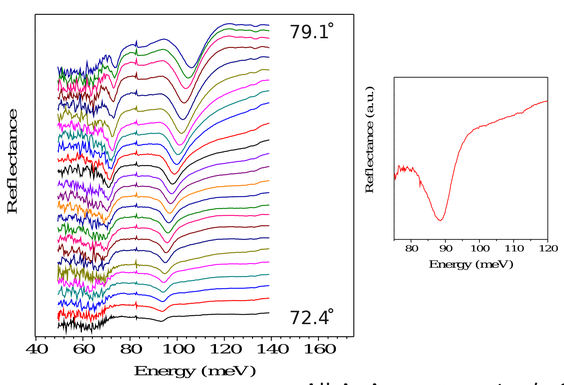
Results

λ = 10 µm



- Clear anticrossing behaviour both at RT and at 4 K
- Rabi splitting of 33 meV : **Ω/ω ~ 13%**

λ = 15 µm

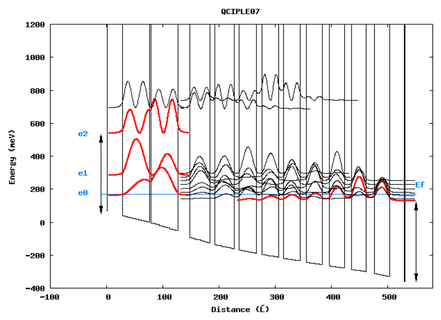


- Rabi splitting of 28 meV : **Ω/ω ~ 17%**

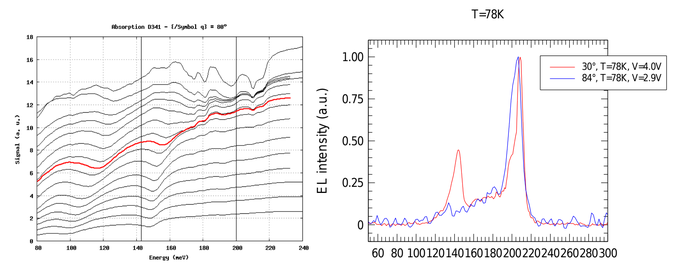
Aji A. Anappara *et. al.*, **Solid Stat. Comm.**, vol. 142-6, pp311 (2007)

Perspectives

Quantum cascade intersubband polariton light emitter

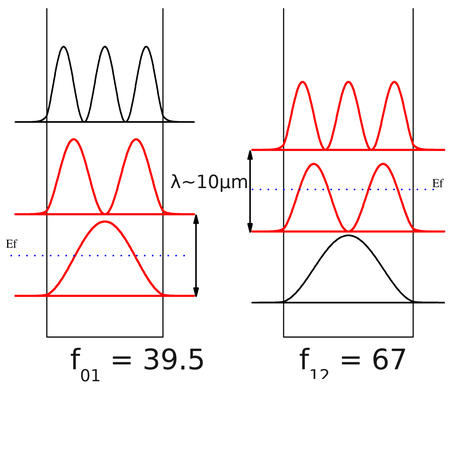


- Resonant tuneling injection to level e2
- Optical cavity resonant with e0-e1 transition



- Significative enhancement of the oscillator strength.

Polaritons with excited subband transitions



- Clear observations of polaritons absorption.
- No evidence of polariton emission.

Conclusion

- Observation of intersubband polaritons in InAs/AlSb heterostructures inside plasmon-enhanced cavity.
- Realization of giant vacuum-Rabi splitting of 33 meV and hight Ω/ω ratio of 17%
- No evidence of Ultra-strong coupling regime.