

# InAs/AlSb structures for giant Rabi splitting of intersubband polaritons

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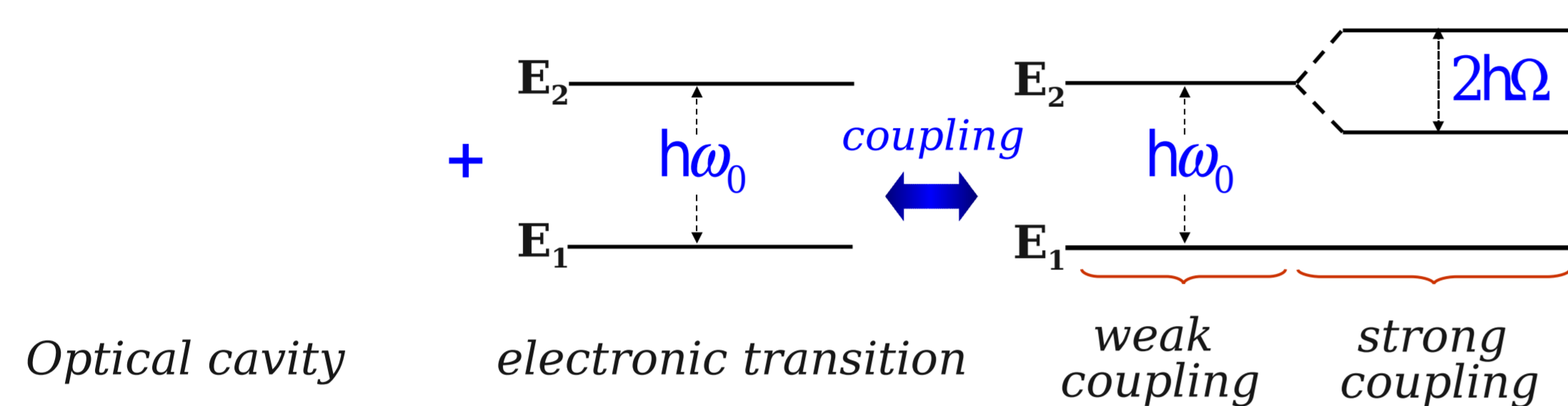
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The optical response of the intersubband excitation of multiple InAs/AlSb quantum wells embedded in a planar semiconductor microcavities has been studied through angle-dependant reflectance measurement. Strong coupling is demonstrated between the intersubband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

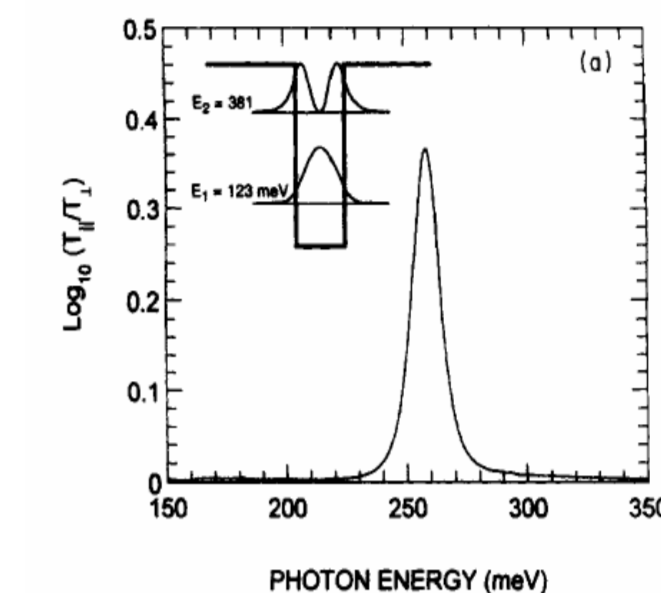
- weak coupling - enhancement/inhibition of spontaneous emission
- strong coupling - vacuum-field Rabi splitting, "cavity-polaritons"



## Intersubband Cavity Polariton

### Intersubband transitions:

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

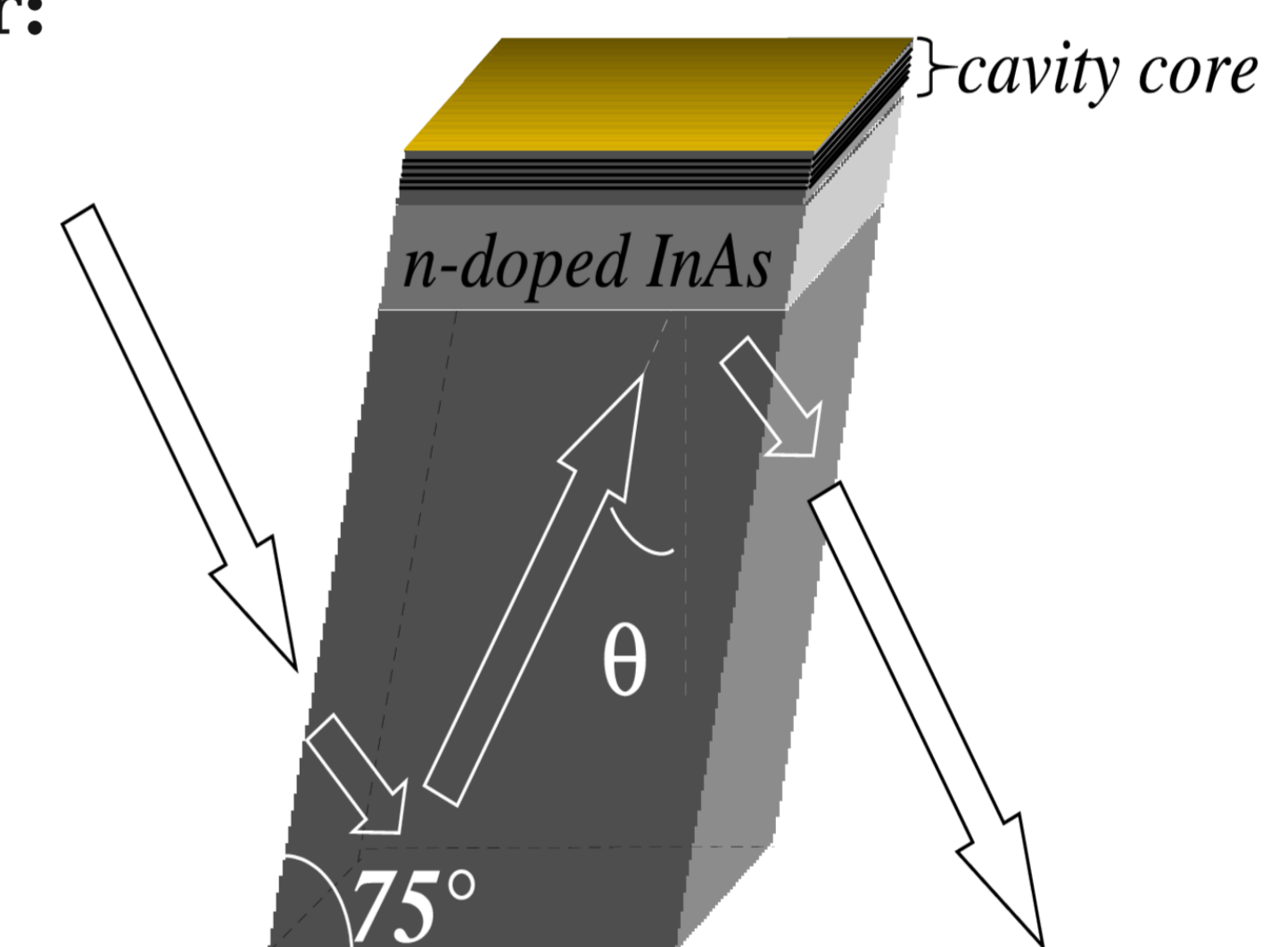


### Important parameters:

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

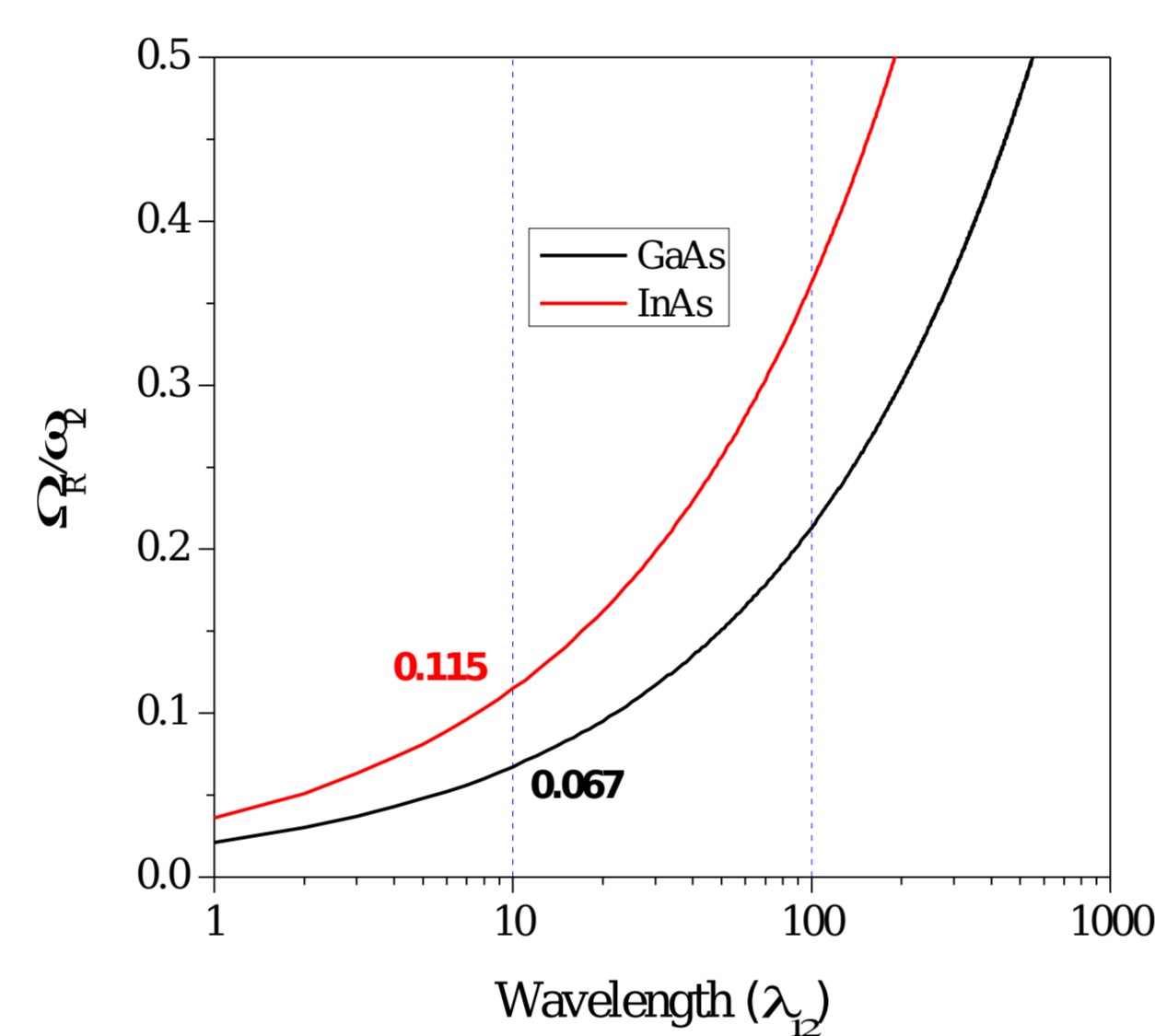
### Intersubband resonator:

- 10 QW active region.
- n-doped InAs cladding layer ( $N \sim 10^{18} \text{ cm}^{-3}$ ).
- Undoped InAs substrate ( $N \sim 3 \cdot 10^{16} \text{ cm}^{-3}$ ).



## InAs/AlSb material system

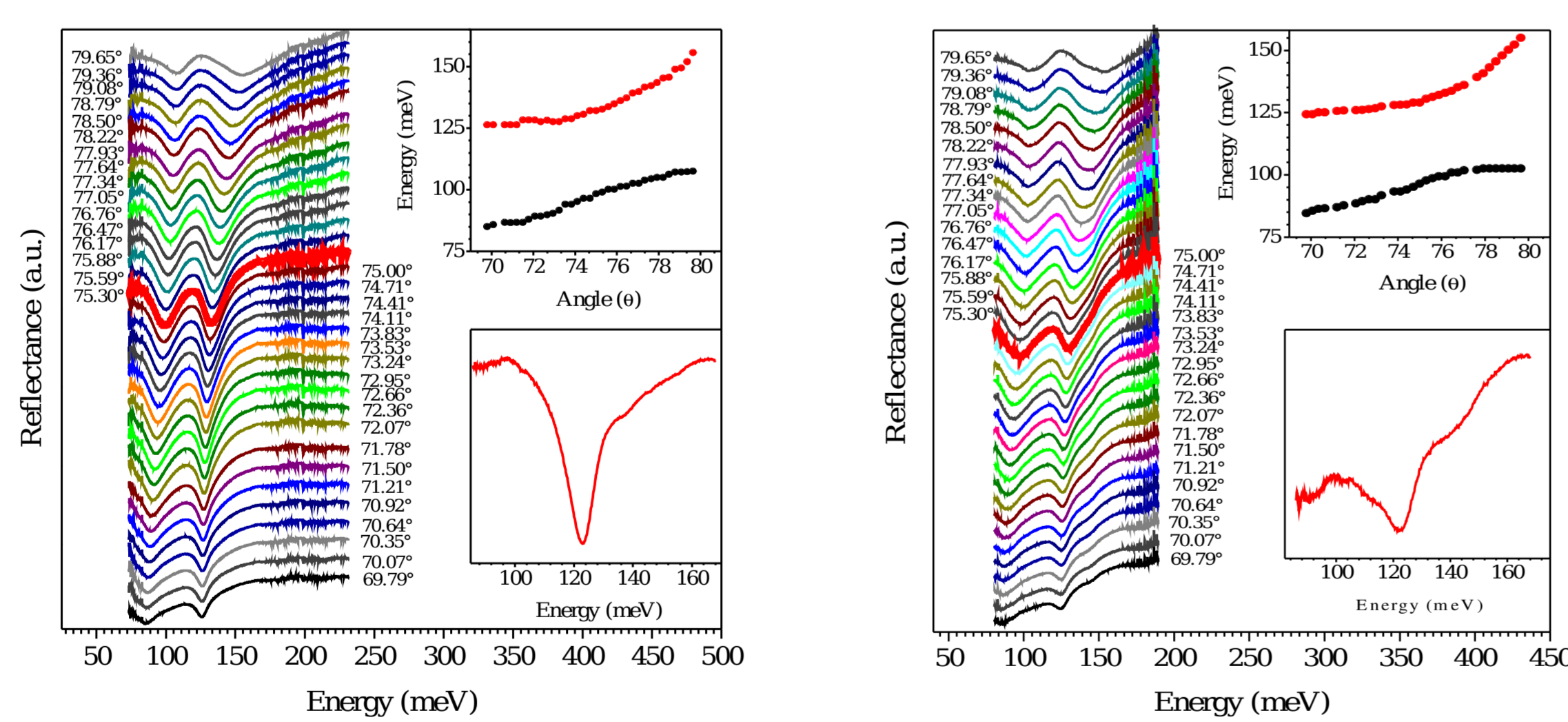
- InAs : Low effective mass
- Enhanced oscillator strength.



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

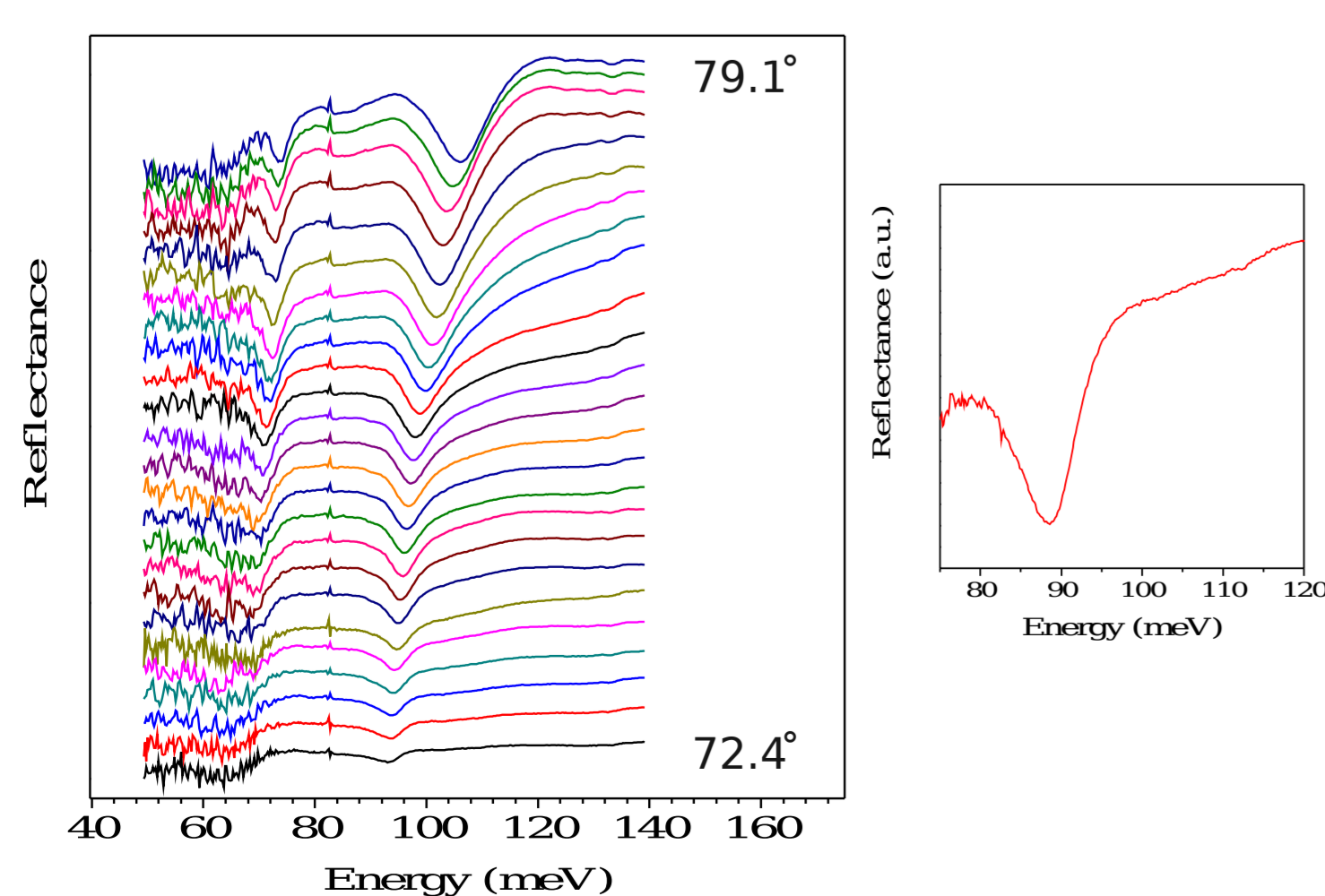
## Results

$\lambda = 10 \mu\text{m}$



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

$\lambda = 15 \mu\text{m}$

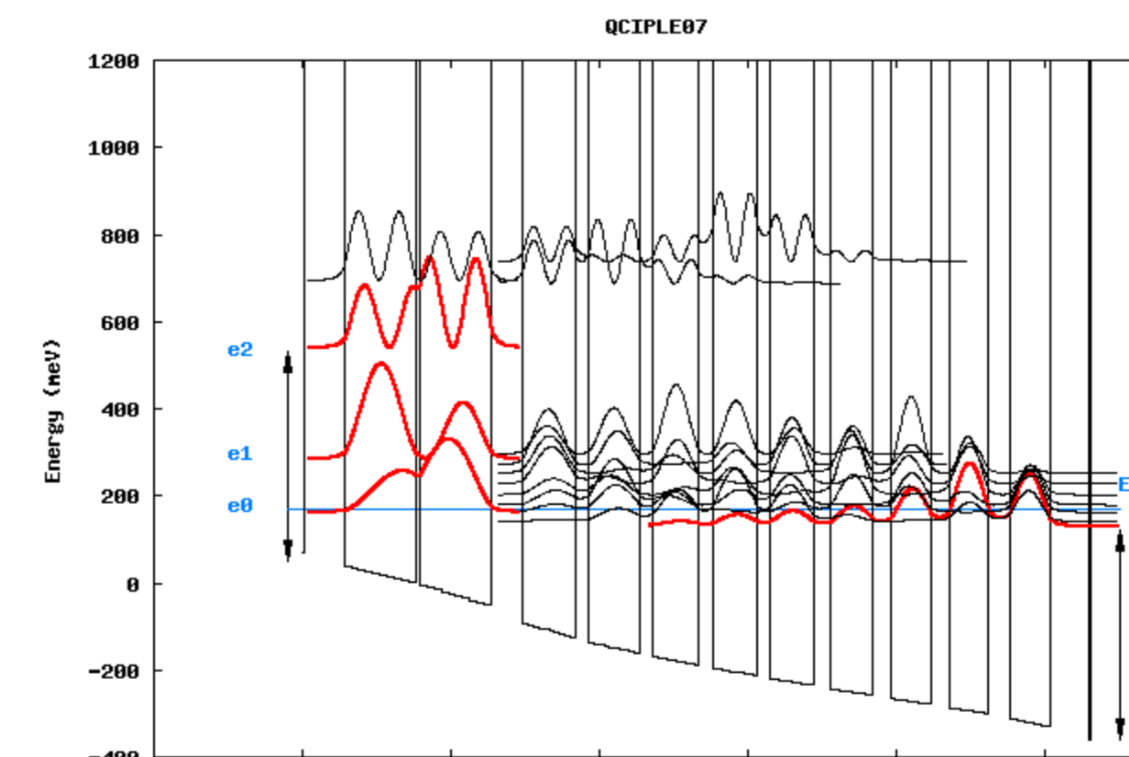


- Rabi splitting of 28 meV :  $\Omega/\omega \sim 17\%$

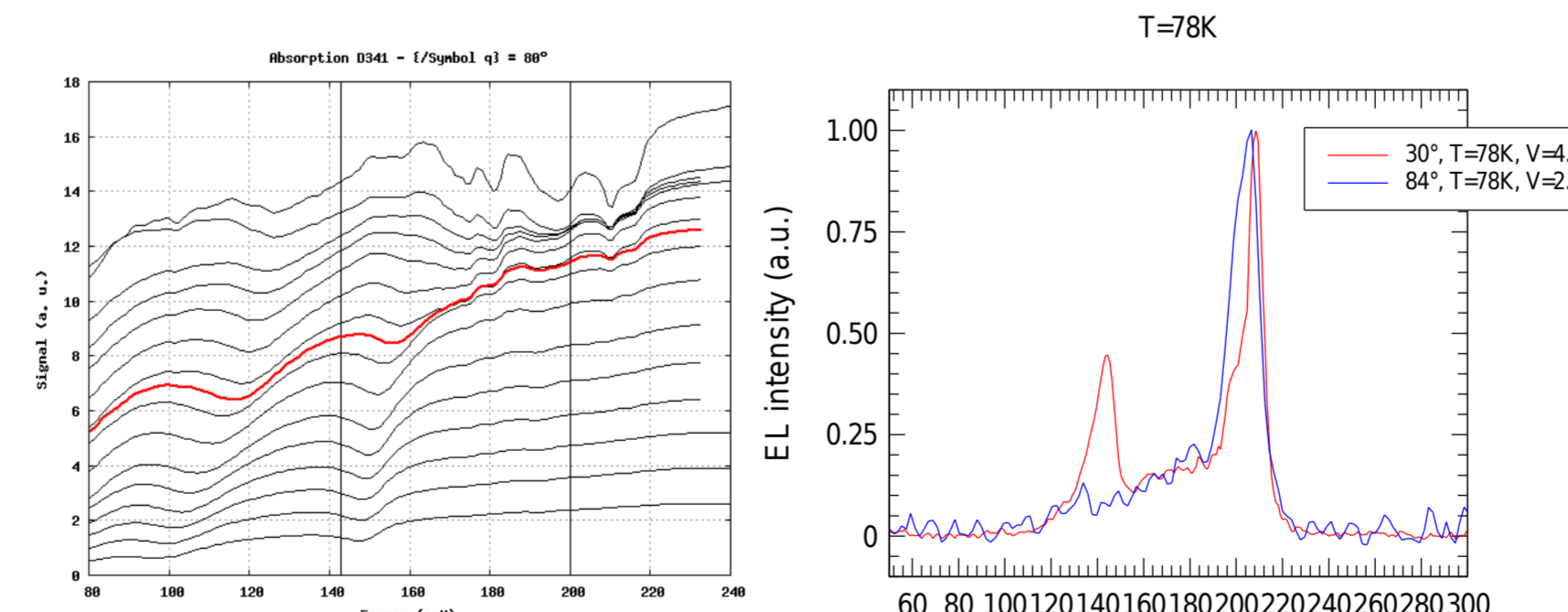
Aji A. Anappara et. al., *Solid Stat. Comm.*, vol. 142-6, pp311 (2007)

## Perspectives

### Quantum cascade intersubband polariton light emitter

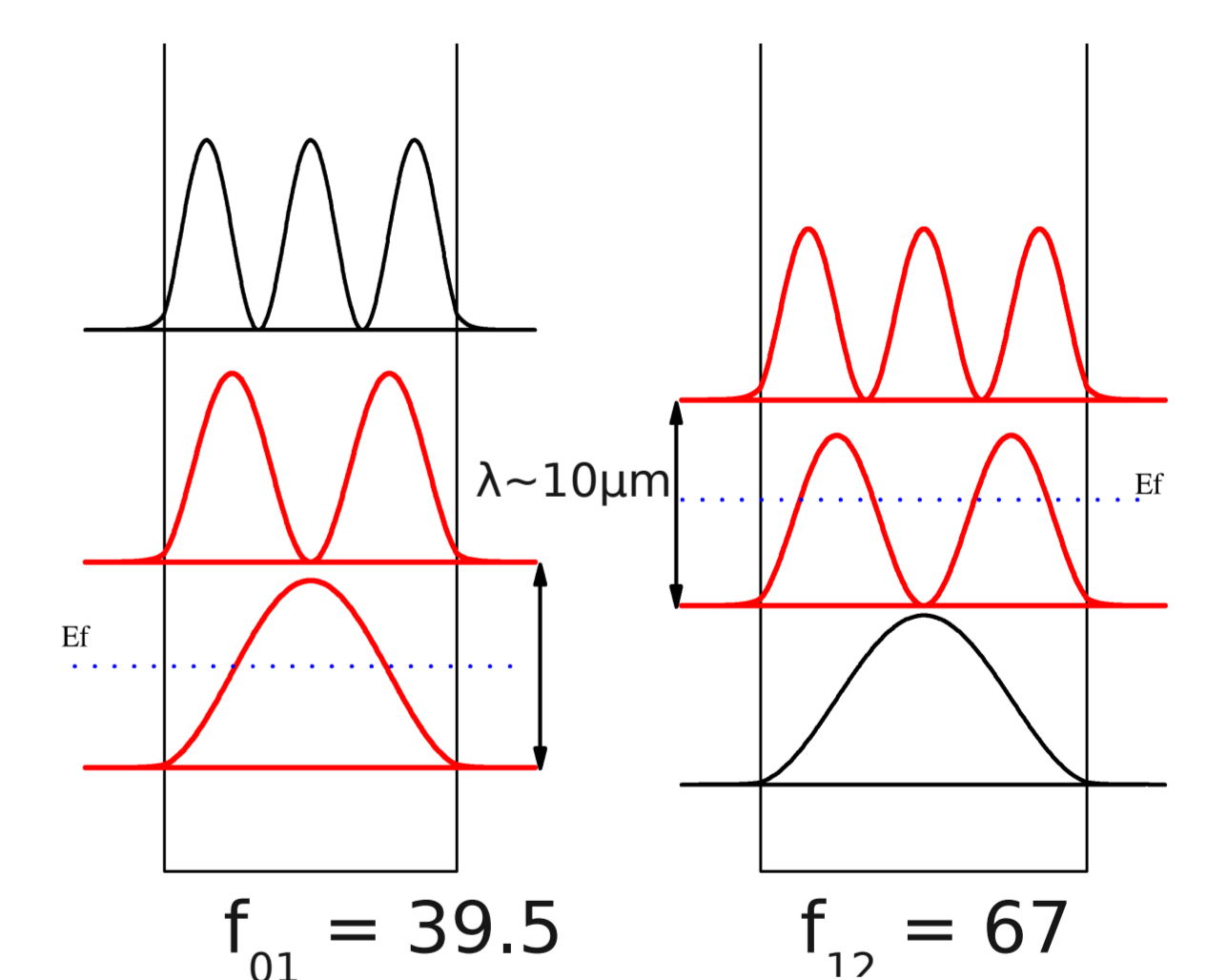


- Resonant tunneling injection to level e2
- Optical cavity resonant with e0-e1 transition



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

### Polaritons with excited subband transitions



- Significant enhancement of the oscillator strength.

## 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.