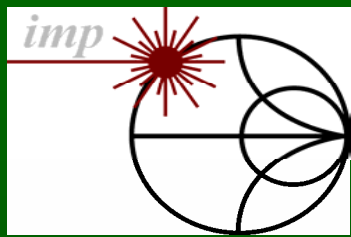


# Interdiffusion Effects on Hole Intersubband Absorption In Complex GaAs/AlGaAs Quantum Well Structures



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## 1. Hole Subband Structure and Intersubband Absorption Calculation in p-doped GaAs/AlGaAs Quantum Well Structures

- Hole intersubband transitions: optically active for both polarizations of light
- Potential applications for IR detectors and for quantum cascade lasers

- 6X6 **k.p** model, fully accounts for anisotropy and nonparabolicity of hole subband dispersion
- Charge self-consistency
- Wavevector dependence of optical matrix elements, and depolarization shift included

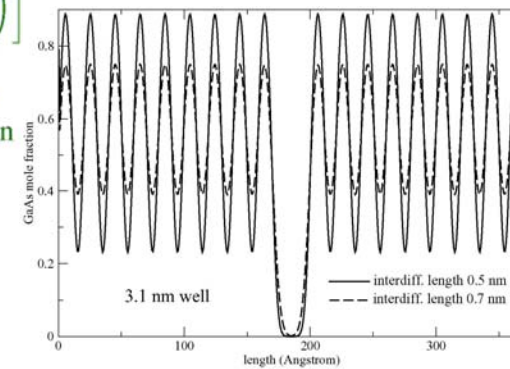
## 3. Interdiffusion

An initially abrupt-interface multilayer structure, with  $N$  layers having the composition  $x_j$  ( $\text{Al}_{x_j}\text{Ga}_{1-x_j}\text{As}$ ),  $j = 1, \dots, N$ , embedded between bulk slabs with composition  $x_0$  on the left and  $x_{N+1}$  on the right, acquires the composition profile

$$x(z,t) = \sum_{j=1}^N \frac{x_j}{2} \left[ \text{Erf} \left( \frac{z-z_{j-1}}{L_d} \right) - \text{Erf} \left( \frac{z-z_j}{L_d} \right) \right] + \frac{x_0}{2} \left[ 1 - \text{Erf} \left( \frac{z-z_0}{L_d} \right) \right] + \frac{x_{N+1}}{2} \left[ 1 + \text{Erf} \left( \frac{z-z_N}{L_d} \right) \right]$$

where  $j$ -th layer boundaries are  $z_{j-1}$  and  $z_j$ , and the interdiffusion length is  $L_d = 2\sqrt{Dt}$ .

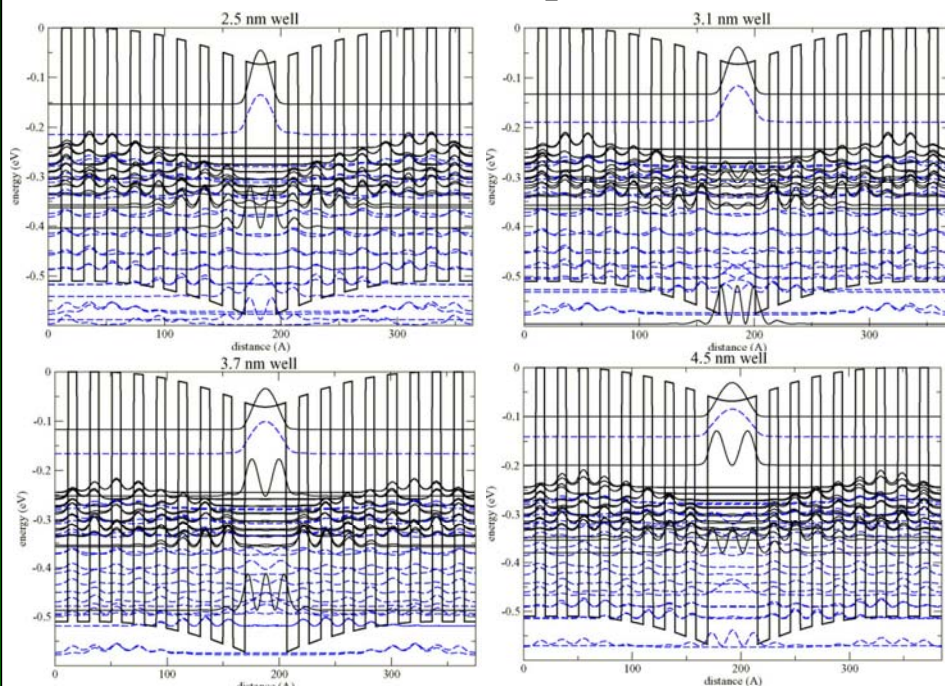
- Interdiffusion significantly distorts the initial profile of thin-layer structures



## 5. Discussion

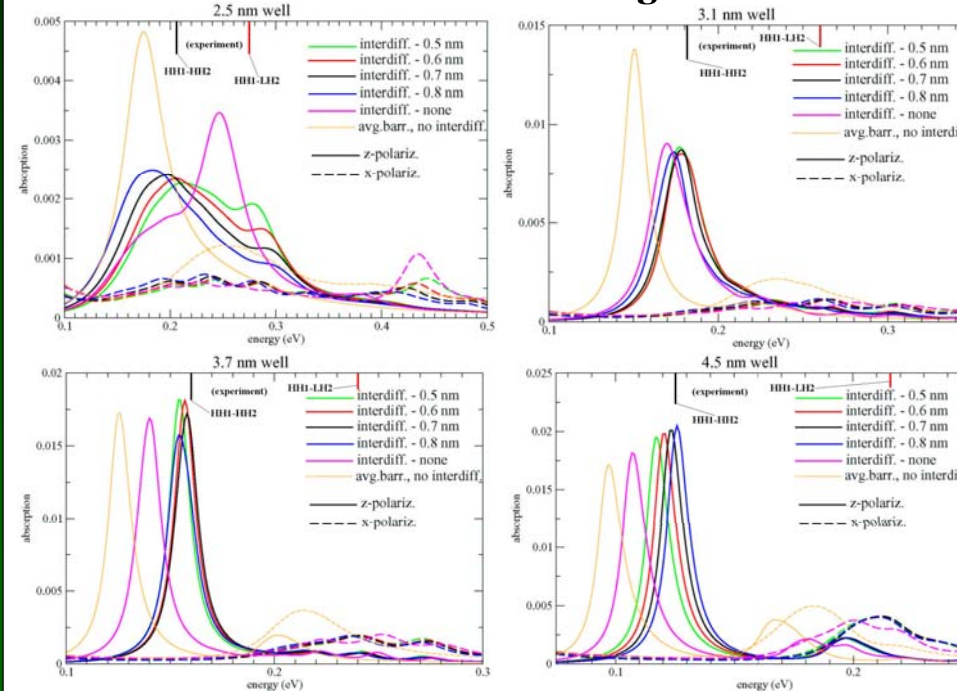
- Including interdiffusion, as well as other effects, is necessary for correct interpretation of hole subband energies in complex GaAs/AlGaAs structures
- The interdiffusion lengths can be deduced from the absorption spectral profiles
- Heavy hole subband energies and the related absorption spectra are predicted very accurately
- There still remains an open question of LH subbands, particularly for high energies (e.g. for LH resonant, unbound states): the 'average barrier' model works better in such cases!

## 2. Quantum Wells in Superlattice Barriers



(O. Malis, et al., Appl. Phys. Lett., 87, 091116 (2005))

## 4. Evolution of Absorption Profiles with Interdiffusion Length



## 6. Discussion (continued)

- This is not the problem of the accuracy of 6X6 **k.p** model (compares well with the EPM based calculation)
- Does the fast scattering (relaxation) of high energy states affect the absorption spectra? Finite coherence length problems? [Still, one period of the superlattice is almost as effective as the full superlattice in the formation of the absorption profile.]

