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 Structuress

- 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

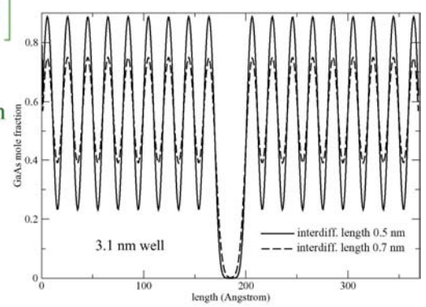
3. Interdiffusion

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

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

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

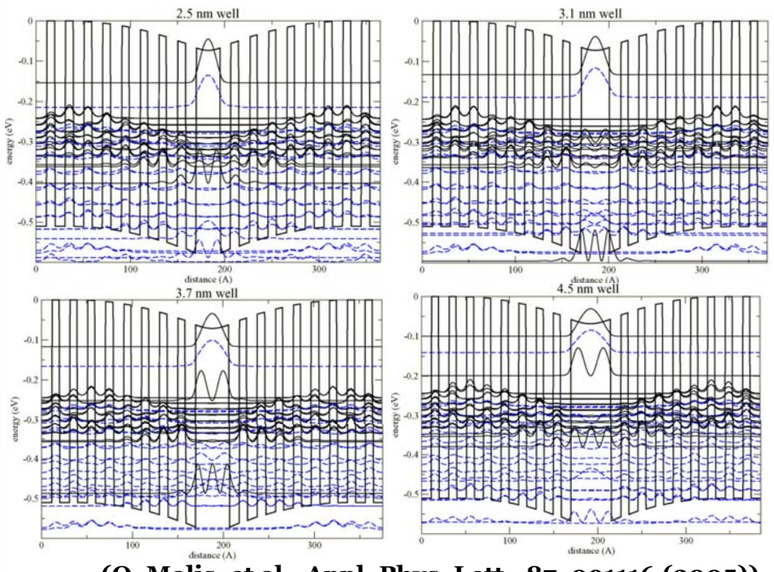
- Interdiffusion significantly distorts the initial profile of thin-layer structures



5. Discussion

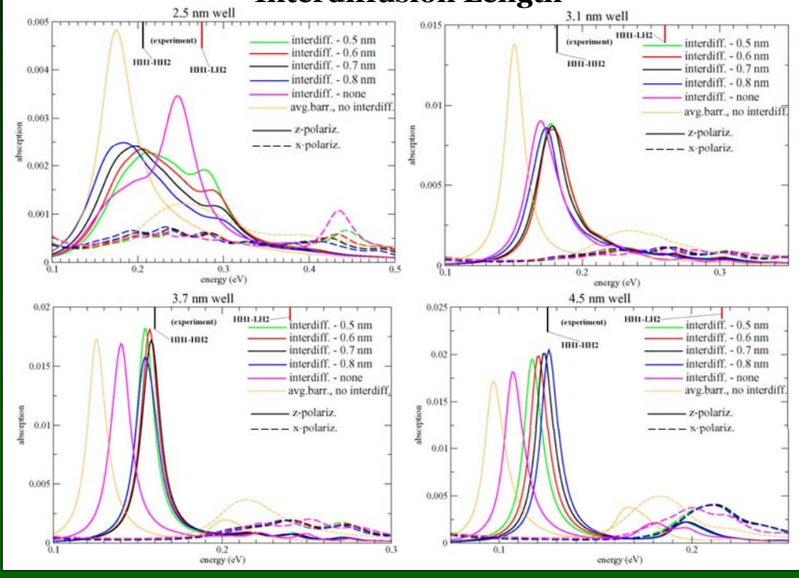
- Including interdiffusion, as well as other effects, is necessary for correct interpretation of hole subband energies in complex GaAs/AlGaAs structures
- The interdiffusion lengths can be deduced from the absorption spectral profiles
- Heavy hole subband energies and the related absorption spectra are 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.]