Physics 8550 – Physics of Thin Films

Assignment #4

(due to March 25, 2008)

1) You have to build an optoelectronic device structure for which you will need GaAs-AlAs multiple layers. The structure consists of 50 repetitions of 10 nm AlAs and 25 nm GaAs layers grown on a GaAs substrate. A 1% accuracy of the structure is required. In you lab, you have a LPE, a OMCVD and a MBE system capable to grow these materials.
   a. What is your recommendation to the technician what growth technique to use. Be convincing with the arguments, since your technician anyway thinks you have no idea!
   b. Your technician is not convinced and wants to use the dipping LPE technique since it is the fastest growth technique and will be done in an hour. What is your reasoning against it?

2) a) How does the surface boundary layer scale with pressure in the gas phase? Explain quantitatively and schematically!
   b. What is the disadvantage/advantage if the gas phase become dense or even a liquid??
   c. How can you reduce / avoid gas phase reactions, which are bad for epitaxial growth?

3) After an OMCVD growth of GaAs, you want to investigate the structural properties and the composition of the layer you grew.
   a. TEM shows you that the layer deposited is poly- crystalline and not epitaxial as you hoped. How and which growth parameter do you adjust the to get better crystalline growth?
   b. TEM shows you also that you got Ga – precipitation. How will get rid of them? Argue with help of the phase diagram fo GaAs.

4) Well, you finally managed to grow epitaxial GaAs and your next goal is to add Al to grow alternative GaAs – $Ga_{0.7}Al_{0.3}As$ heterostructures.
   a. How do you control the composition of Ga and Al to be 70:30? What is the difference in the sticking coefficients for these both? What kind of precursor do you use and why?
   b. What techniques do you use to verify the quality of your layers? Name at least two in each category: structural / compositional / electrical / and optical properties.