3.46 PHOTONIC MATERIALS AND DEVICES
Homework Assignment 7—April 12, 2006
Due: April 19, 2006

1. In-Plane (Biaxial) Strain in Ge Thin Films

Please refer to the Applied Physics Letter "Deformation Potential Constants of Biaxially Tensile Stressed Ge Epitaxial Films on Si(100)," by J. Liu et al. (Materials link, Lecture 14, Lecture Notes 3.46.)

(a) What is the physical origin of the Deformation Potential?

(b) What is the influence of compression/tension on the bandgap of Ge thin films?

(c) The indirect bandgap (conduction band X-point $\rightarrow$ valence band Γ-point) for Ge is E_g = 0.66 eV (at room temperature). Theoretical predictions of the Deformation Potential predict that while the Γ-point of the conduction band shifts as a result of in-plane strain, the X-point is approximately constant. At what value in-plane strain will the direct bandgap transition become equal in energy to the indirect bandgap transition?

(d) Is this value of in-plane strain feasible for a coherent 4μm thick film? Justify.

2. Defect Failure Mechanisms in Laser Diodes

Please refer to the paper "The Influence of Electronic Excitation on the Performance and Reliability of Semiconductor Devices," by L. C. Kimerling (Materials link, Lecture 14, on the Lecture Notes, 3.46).

(a) (Refer to section 2.1) When studying the Dark-Line Defect failure mechanisms for semiconductor laser diodes,

  (i) What is the role of non-stoichiometry?
  (ii) What is the role of threading dislocations?
  (iii) What is the role of Recombination Enhanced Diffusion Reaction?

(b) Propose two material processing solutions to counter this failure mechanism and thus increase the room temperature operating lifetime of laser diodes.