3.22 Mechanical Properties of Materials
Spring 2008

Multidimensional Defects in III-V Semiconductors

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[1] Image by Andy Kim; http://sauvignon.mit.edu

"Cross-sectional TEM image of InGa(1-x)P/GaP compositionally graded buffer."

Big Picture: III-V Devices

- Applications: high speed electronics, optical (GaAs: red; GaN: blue; green?)
- Mechanical properties:
  - Substrate handling
  - Avoid delamination
- Importance of defects:
  - Point defects: electronic properties
  - Line defects:
    - electronic properties
    - mechanical properties
  - Temperature effect
    - processing
    - during device operation
  - Avoid in active region
- Thin films: graded buffers often used
  - Avoid dislocations in substrate

Image removed due to copyright restrictions. Please see http://www-opto.e-technik.uni-ulm.de/lehre/cs/III_V_map_a.jpg

[2] Compound semiconductors: Physics, technology and device concepts." 2007. <http://www-opto.e-technik.uni-ulm.de/lehre/cs/index.html>.

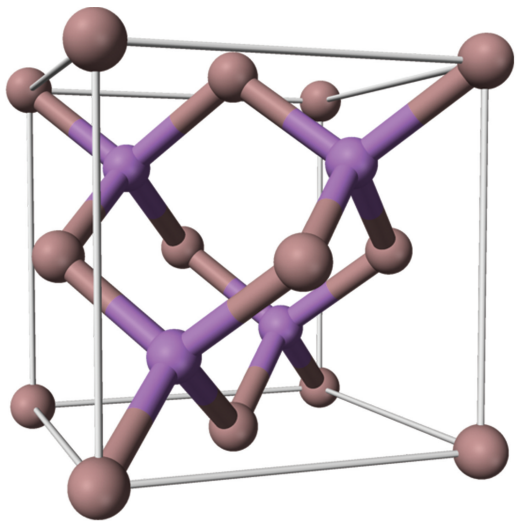
Microscopic mechanism

GaAs thin films:

•Anisotropy of the stiffness tensor:
Crystal structure, 3 independent constants

•Thickness dependence of K_IC :
Nanoindentation : mixed mode loading.
Thin film: insufficient thickness

•Interaction matrix



[1]

Images removed due to copyright restrictions. Please see http://www-vrl.umich.edu/project2/miller/111plane.JPG [2] and Fig. 2 in [3].

[1] Wikimedia Commons, http://commons.wikimedia.org
[2] http://www-vrl.umich.edu/project2/miller/index.htm
[3] Hjort, Klas, Jan Soderkvist, and Jan-Ake Schweitz. "Gallium arsenide as a mechanical material." *Journal of Micromechanics and Microengeneering* 4 (1994): 1-13.

Prediction & Optimization

- Prediction:
  Growth of thin films along <111> direction
  Thickness beyond which K_IC is constant.

- Optimization
  Strong substrate for ease of handling
  Inherent difficulty: 2+ element basis
  Graded buffers: threading dislocations glide to wafer edge

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Please see Fig. 1 and 3a in [3].

[3] Hjort, Klas, Jan Soderkvist, and Jan-Ake Schweitz. “Gallium arsenide as a mechanical material.” *Journal of Micromechanics and Microengengineering* 4 (1994): 1-13.