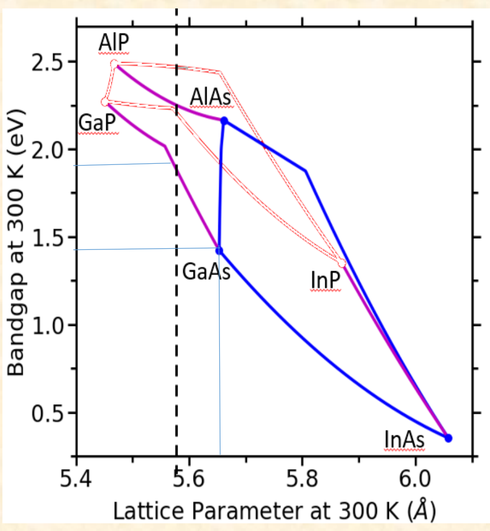
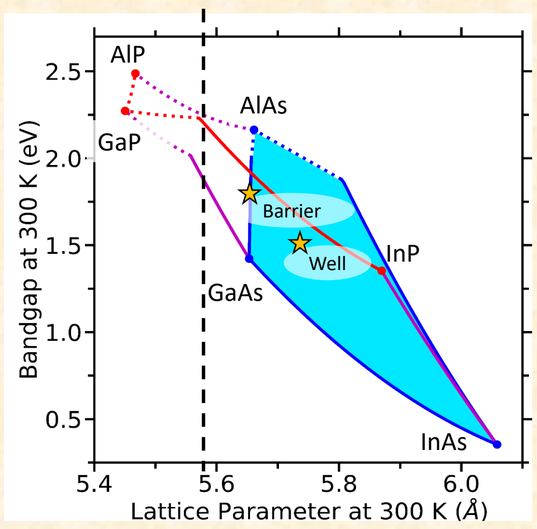
High Polarization Photocathodes: UCSB & JLab

Re-visiting InAlGaAs/AlGaAs

Marcy Stutzman (JLab) Aaron Engle & Chris Palmstrøm (UCSB), Greg Blume (ODU)

Composition

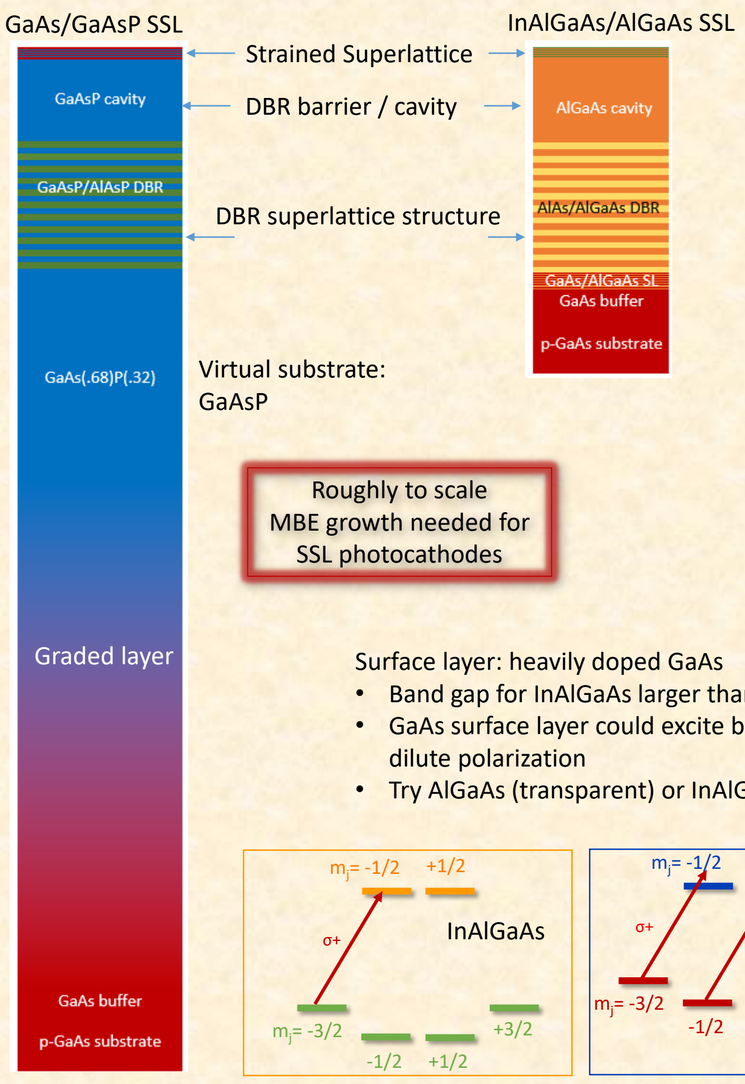




GaAs/GaAsP superlattice
1. Requires graded layer
2. High vapor residue
3. Growth Temp mismatch
4. Wavelength and strain dependent
5. DBR structure: different composition
6. Great Results: 85+% Pol, 1% QE

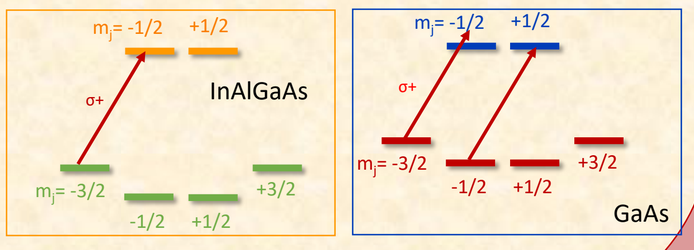
InAlGaAs/AlGaAs superlattice
1. Grow AlGaAs directly on GaAS
2. Common MBE elements
3. Good temperature match
4. Wavelength and strain independent
5. DBR structure very compatible
6. Best Results: comparable

Based on Mamaev et al., Appl. Phys. Lett. 93, 081114 (2008)

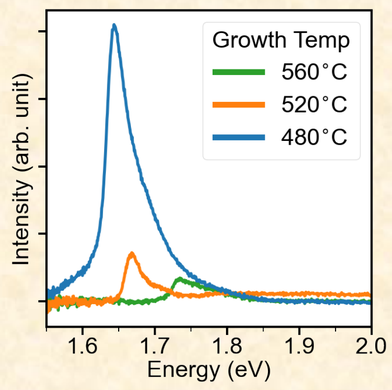


Roughly to scale
MBE growth needed for SSL photocathodes

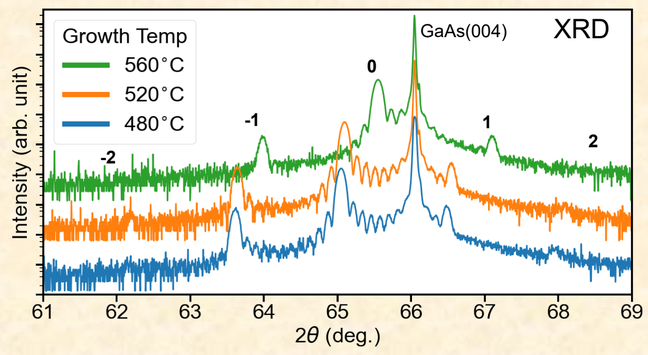
Surface layer: heavily doped GaAs
- Band gap for InAlGaAs larger than for GaAs
- GaAs surface layer could excite both bands, dilute polarization
- Try AlGaAs (transparent) or InAlGaAs surface?



Temperature Variation



Photoluminescence shows more intense peak at lower temperature

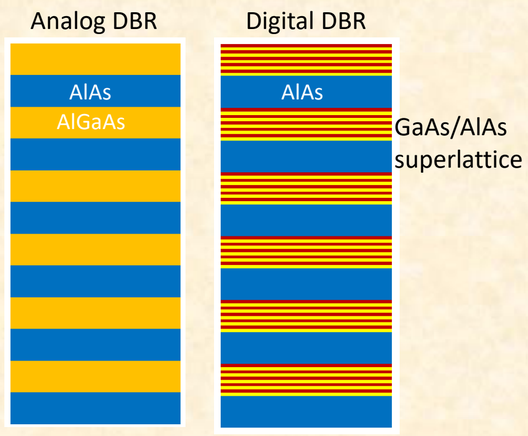


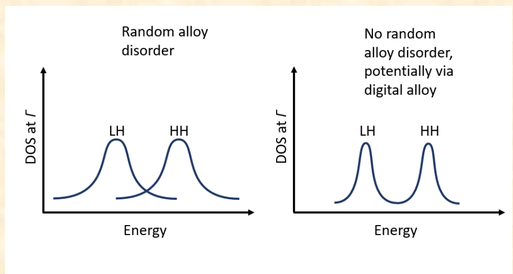
X-ray diffraction shows sharper superlattice interfaces at lower temperature

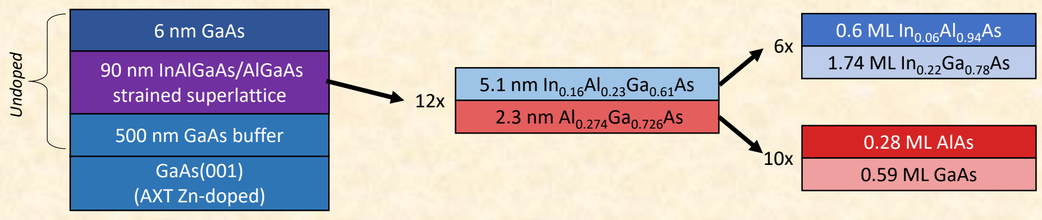
Analog vs. Digital Growth

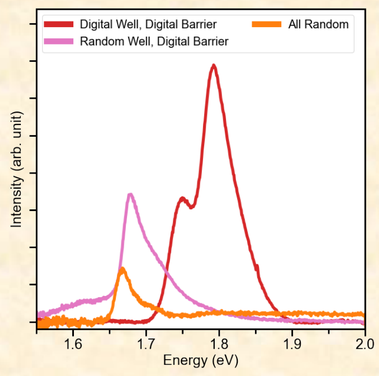
Quartenary Alloy InAlGaAs can introduce non-uniformity

Digital alloy: Layers of simpler alloy instead of co-deposition

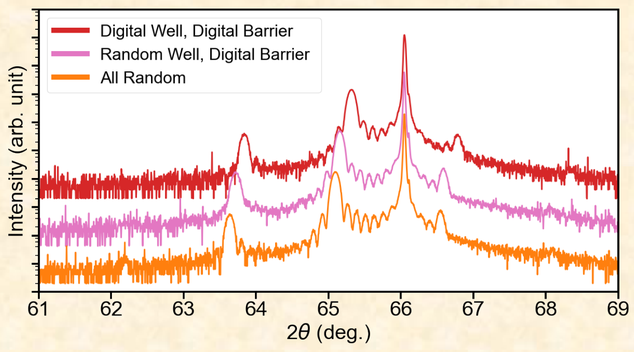






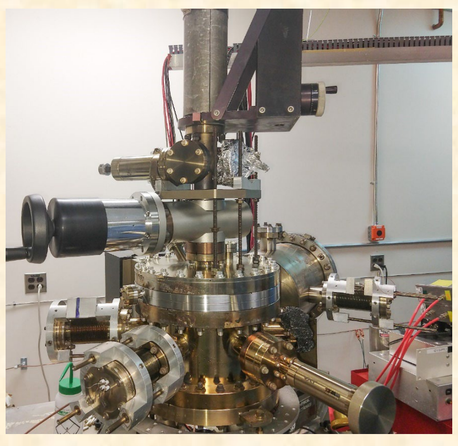


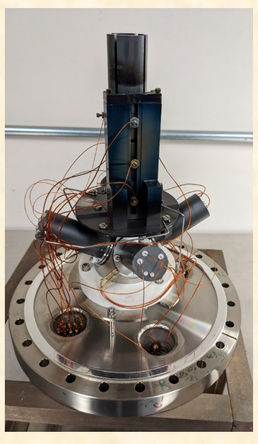
PL: improves with digital alloy barriers or wells



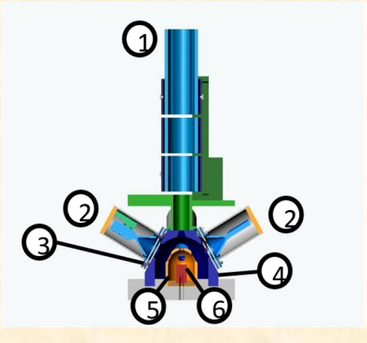
XRD: Similar to analog

JLab MicroMott Polarimeter



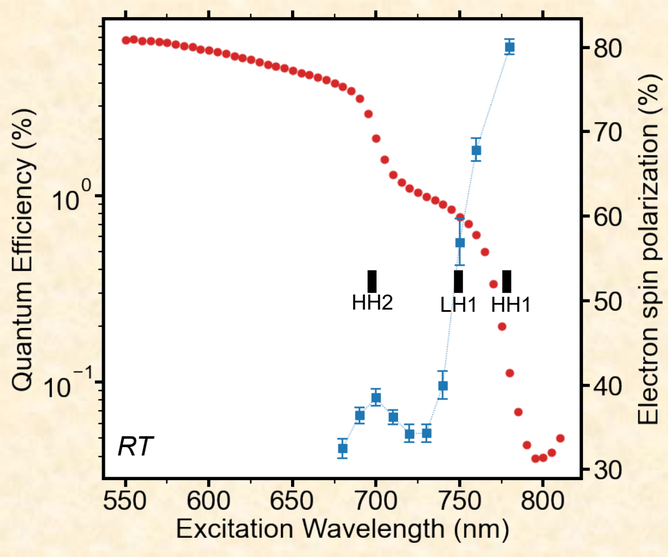


1. Lenses
2. CEM
3. Grids
4. Outer Hemi
5. Inner Hemi
6. Target



McCarter, J. L., Stutzman, M. L., Trantham, K. W., Anderson, T. G., Cook, A. M., and Gay, T. J.. *A low-voltage retarding-field Mott polarimeter for photocathode characterization*. United States: N. p., 2010. Web. doi:10.1016/j.nima.2010.02.123.

Results & Next Steps



520°C growth temperature
- 82.5% Polarization, 0.34% QE at 780 nm
  - Decent first try
- Heavy Hole/Light hole bands split
  - ~50 meV

More samples ready to test
- 480°C and 560°C: samples 198, 199
- Increased strain: sample 144
- Higher dopant top and band gap shift: sample 143
- Digital alloy barrier layer: Sample 202

Awaiting polarimetry feedback

DBR structure grown and analyzed
- Ready to grow SSL on DBR

Jefferson Lab

U.S. DEPARTMENT OF ENERGY

JSA