GaInNAs Lasers

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Outline

- Applications, why the interest?
- Previous option (InGaAsP)
  - Problems
- GaInNAs Material Properties
  - Benefits
- Research Results
  - Issues and future work

Applications

- Network capacity is increasing exponentially
  - Gilder's Law – "Communication Capacity will triple every 12 months"
- Need long wavelength, high speed, low cost VCSEL

Applications

- Advantages of long wavelengths (>1300nm) relative to short wavelengths (850nm)

Material Properties

InGaAsP as an Option

- InGaAsP/InP is the current material system in use in VCSELs for 1.3/1.55 μm
- Major problems and disadvantages:
  - High cost
- Poor T performance:
  - Small band offset (leads to To~70K)
  - DBRs have low thermal conductivity
- Unsatisfactory VCSEL performance:
  - Poor DBR mirrors
  - Elaborate Structure/More cost
- **GaInNAs offers several benefits**

Compared to GaInNAs

- Larger refractive index differences
  - Step difference Δn(AlGaAs)> Δn(InGaAsP)
  - Easier to make high reflectivity DBRs
- Thermal conductivity
  - Bottom DBR acts as better heat sink
- Cheaper GaAs substrates
- Larger conduction band offset
  - Better temperature performance

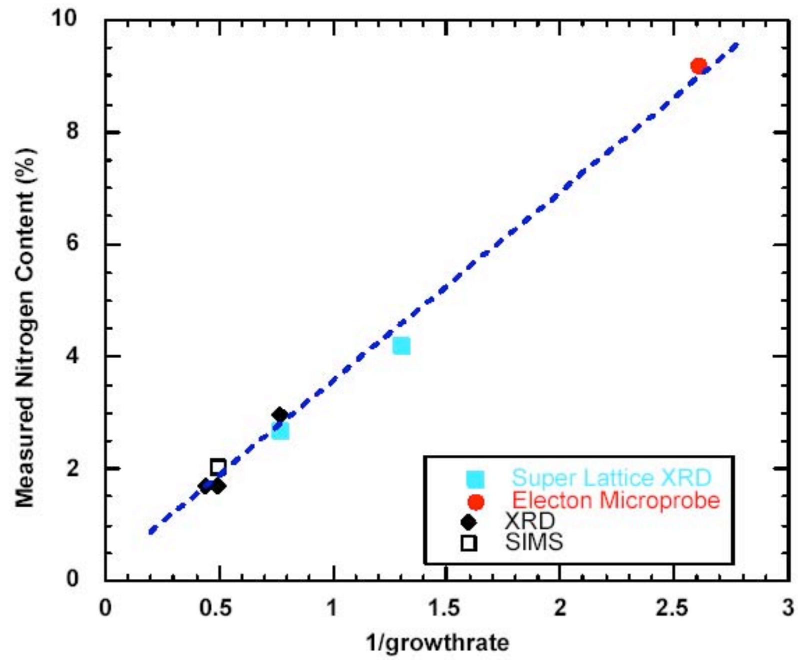
Material Properties

- Adding In
  - Ec_
  - Ev_
  - Compressive strain
- Adding N
  - Ec _
  - Ev _
  - Tensile strian
- At A&D introduce N
  - Can grow GaInNAs lattice-matched to GaAs

Material Properties

- Achieve type-I band lineup
- Much greater □Ec for GaInNAs
  - -Suppresses electron overflow from QW
  - -dramatically improves temperature characteristics

Growth



- Grown by MBE with RF nitrogen plasma
- N incorporated with unity sticking coefficient
  - Better yield and reproducibility

Research

- VCSEL structure
  - Mesa etch
  - AlOx aperture

Research

- First generation VCSEL design
- 1200nm output
  - CW at room temperature
  - J_{th}≈$2kA/cm^2$
  - Slope efficiency≈0.05W/A

Research

- Add Sb to well layer
  - More In content
- Add N, Sb to barrier layer
  - Strain compensation
- Increase output wavelength
- Added complexity

Research

- Difficulties
  - Significant defect related recombination
  - Poor solubility of N in GaAs
  - 5 component system
  - Harder to make Bragg mirrors by MBE
- Conclusion
  - Good T characteristics
  - All epitaxial growth
  - Best contender for low-cost telecom VCSELs

Thank you

- **References**

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