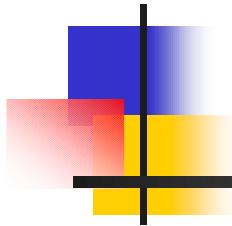


Far-infrared Generation in Sb-based Quantum Wells Pumped by Near-infrared Diode Lasers



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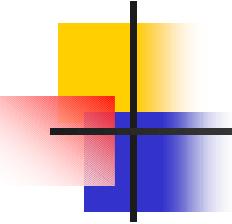
D.C. Larrabee, J.Tang, G.Khodaparast, J.Kono

ECE Department, Rice University, Houston, TX 77251

S.Sasa and M.Inoue

EE Department, Osaka Institute of Technology, Japan



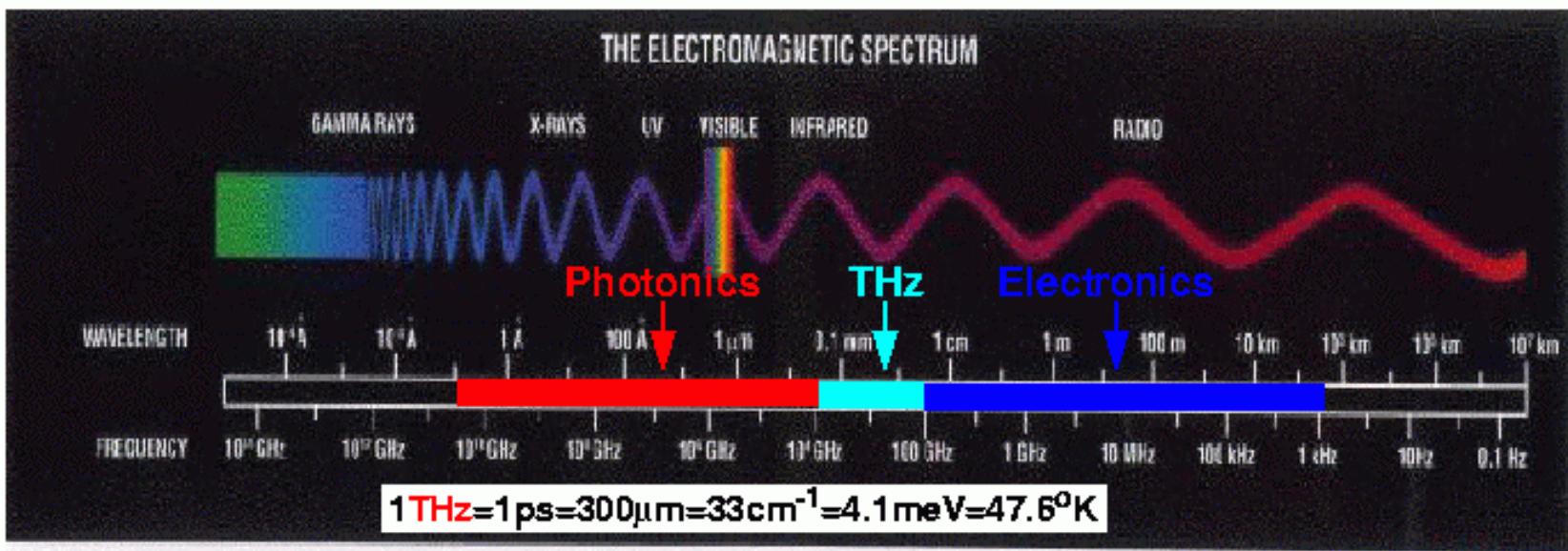


Outline

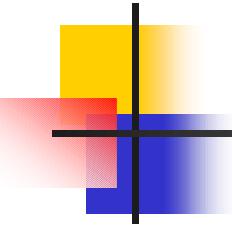
- Introduction
- THz Gain: Intersubband Pumping and Raman Enhancement in InGaAs/InP/AlAsSb QWs
- DR-DFG in Deep QWs
- InAs/GaSb/AlSb QW Systems
- Summary

Terahertz Field: A Technology Gap

- No compact THz sources available



- Frequency too high for electronics and too low for photonics
- No mature solid state technology for both generation and detection

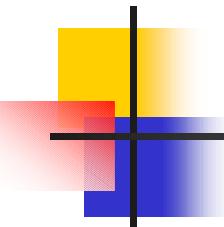


Existing THz Sources

- Molecular lasers pumped by another laser (e.g., methanol laser pumped by CO₂ laser (JPL for the EOS satellite))
- Free-Electron lasers
- Parametric generators, photomixers in non-semiconductors
- Ultrafast laser generation of oscillating charge carriers

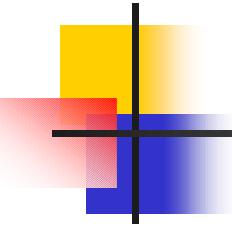
Shortcomings:

- Low output power
- Inefficient
- Bulky (need big pump lasers)
- Incoherent (not lasers)



Applications of THz Wave

- Terahertz modulation and switching
- Chemical, biochemical, and astrobiological detection and sensing
- Materials and security Inspection
- High bandwidth, energy efficient, secure data link
- ..., many more applications



Introduction: Whys

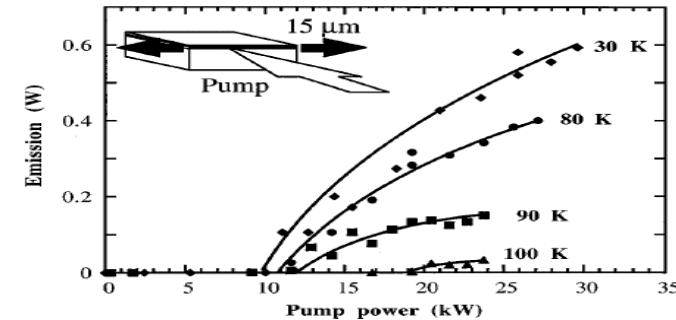
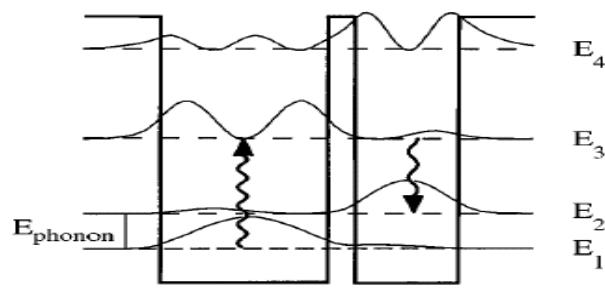
- Why Intersubband?
 - Long wavelength generation
 - Diminished Auger processes
 - Large transition matrix elements
- Why Sb-QWs? (unique bandedge lineups)
 - Flexibility in wavelength design
 - Deep conduction band wells allowing **NIR (diode) laser pumping**

Introduction: Whys

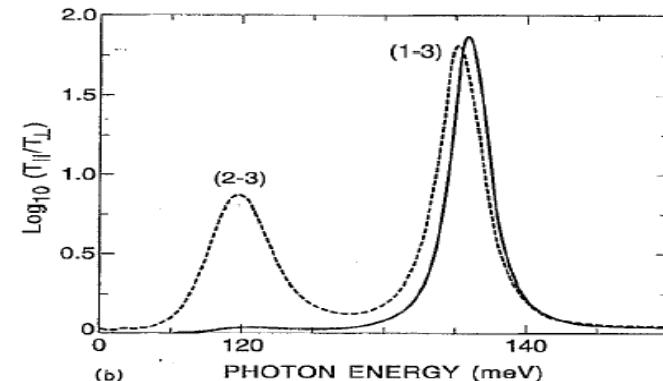
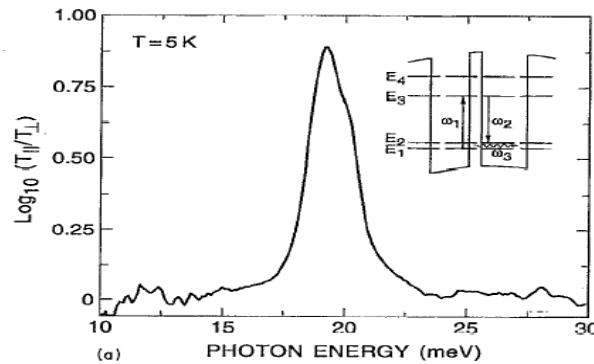
- Why optical pumping?
 - Less reliant on population inversion
 - Utilization of resonant nonlinearities
 - Lower carrier concentration and lower free carrier absorption
 - Absence of heavily doped layers for contacts and injectors
 - Potential integration if diode lasers used as pumping

Introduction: Present Approach

- CO₂ laser pumped GaAs/AlGaAs QWs emitting 15.5mm (Paris-Sud)

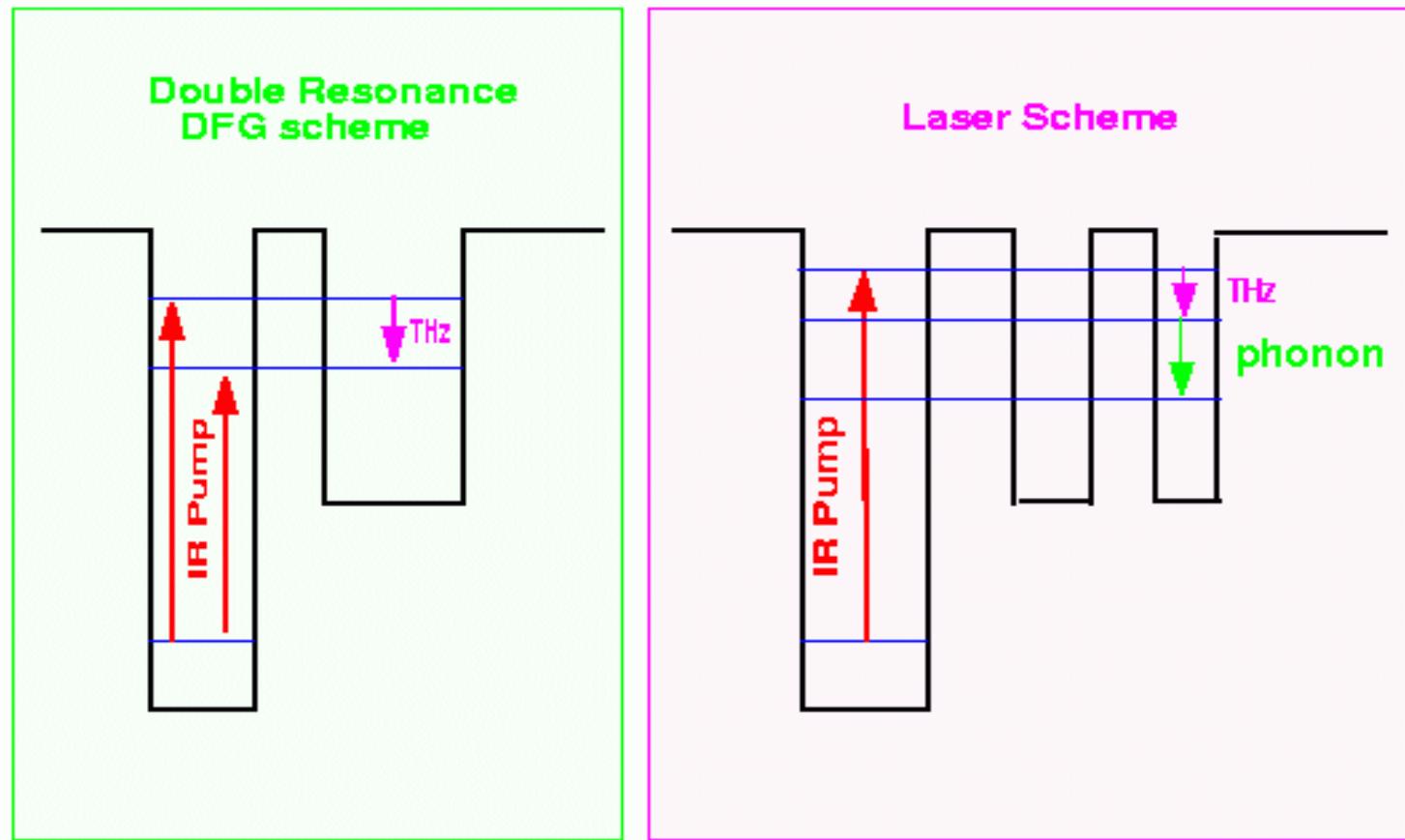


- FIR Generation by Double-Resonant DFG (Lucent)

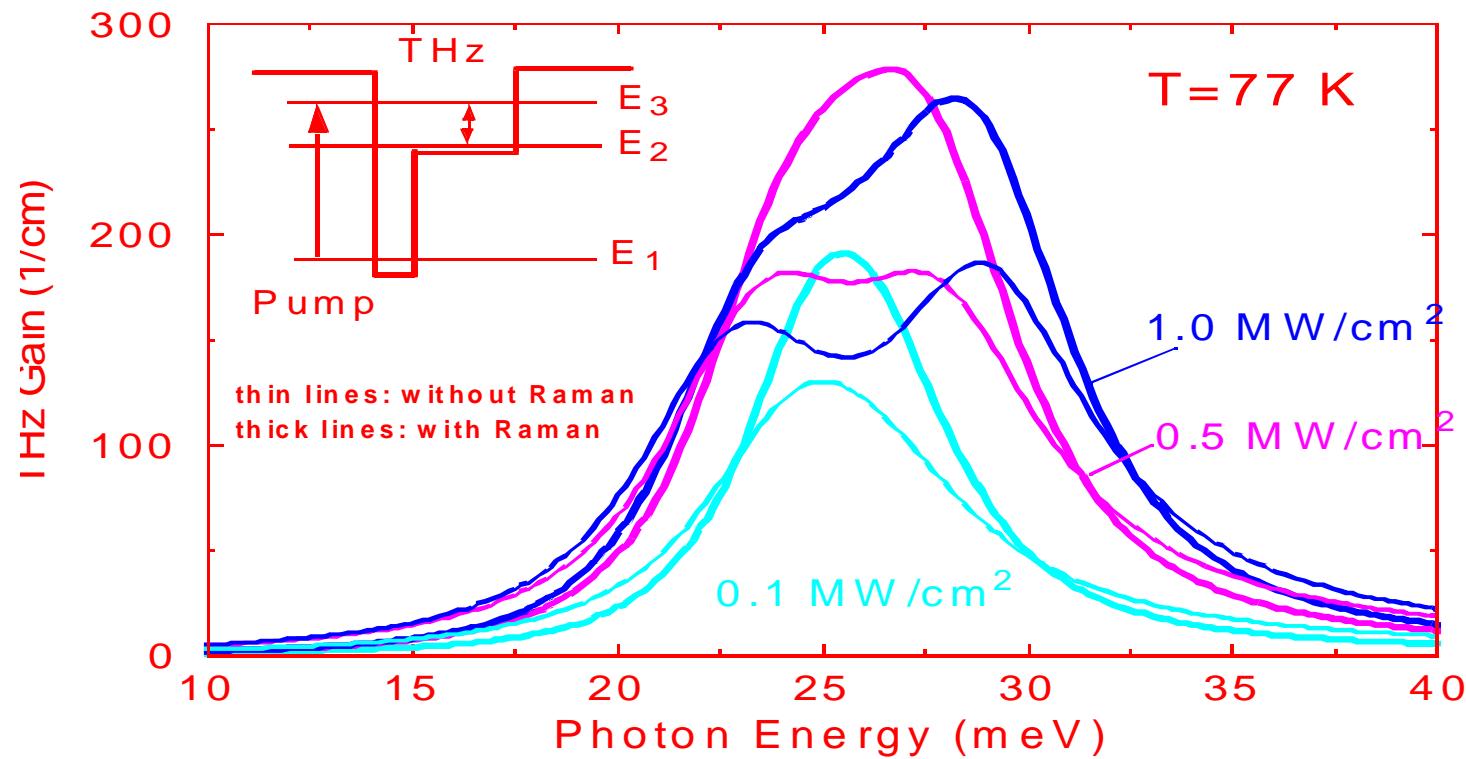


Proposed Solution:

Diode Laser Pumped QW-Intersubband Based THz Sources

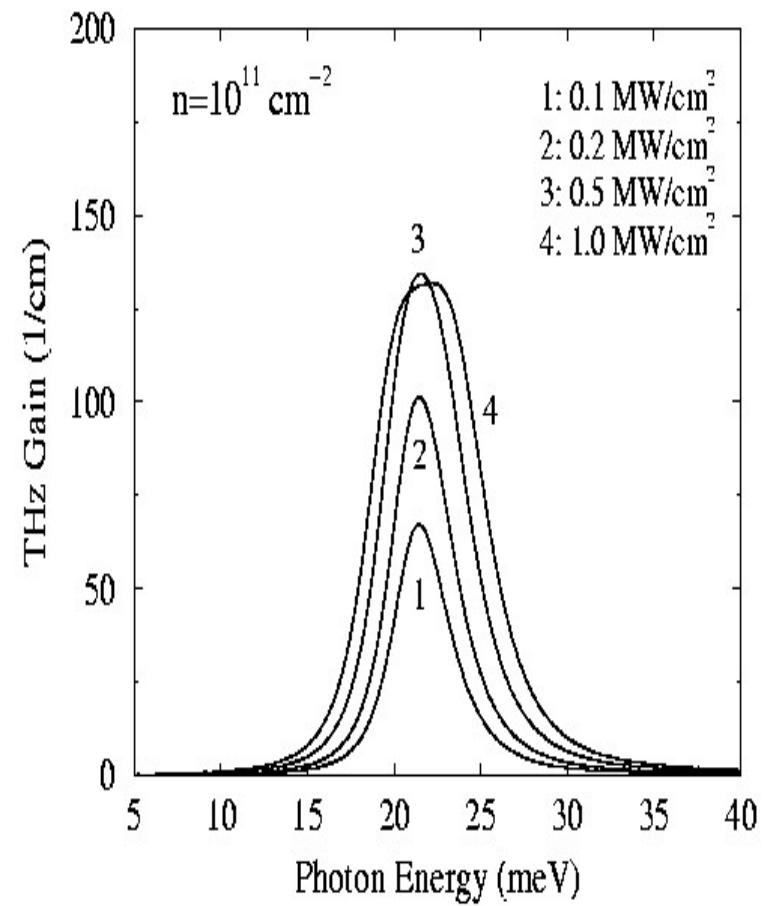
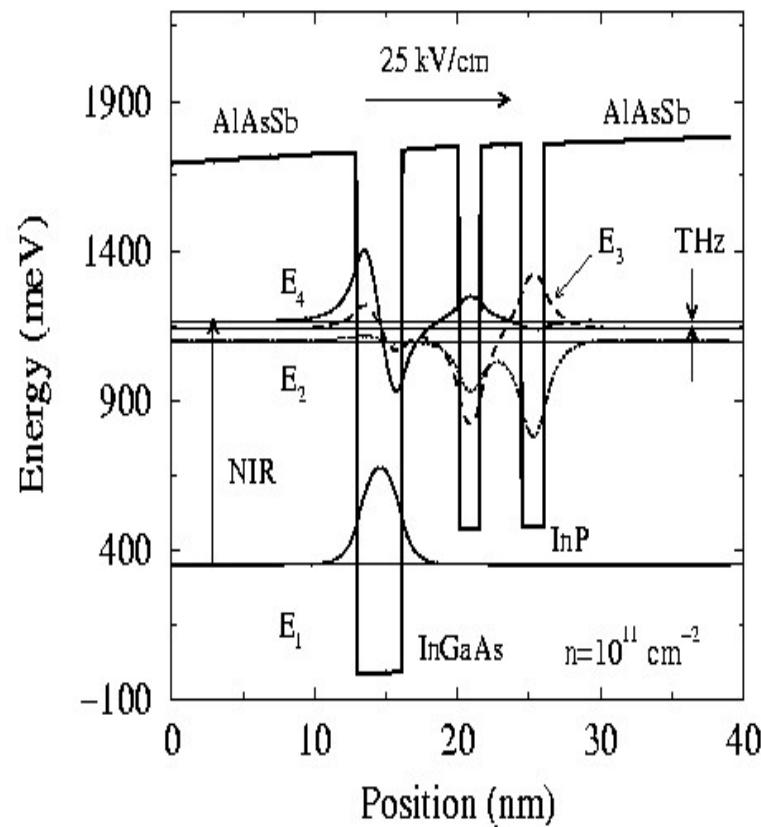


Raman Enhanced Optical Gain



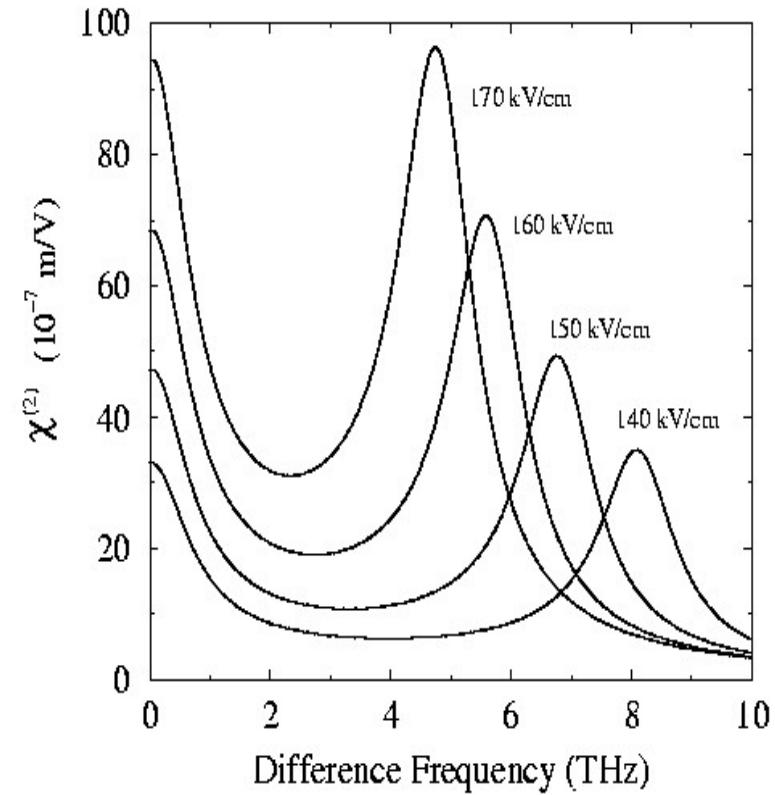
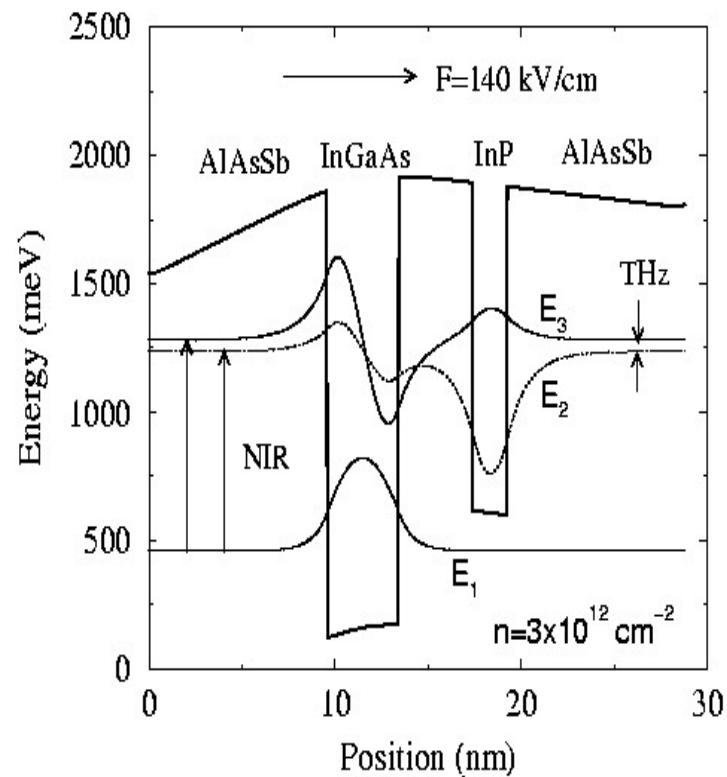
A. Liu and C.Z. Ning, Applied Physics Letters, 75, 1207(1999)

THz Laser Gain in InGaAs/InP/AlAsSb Quantum Wells

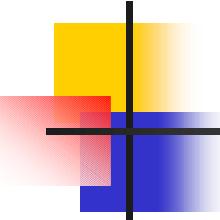


Liu and Ning, APL, 76, 1984(2000)

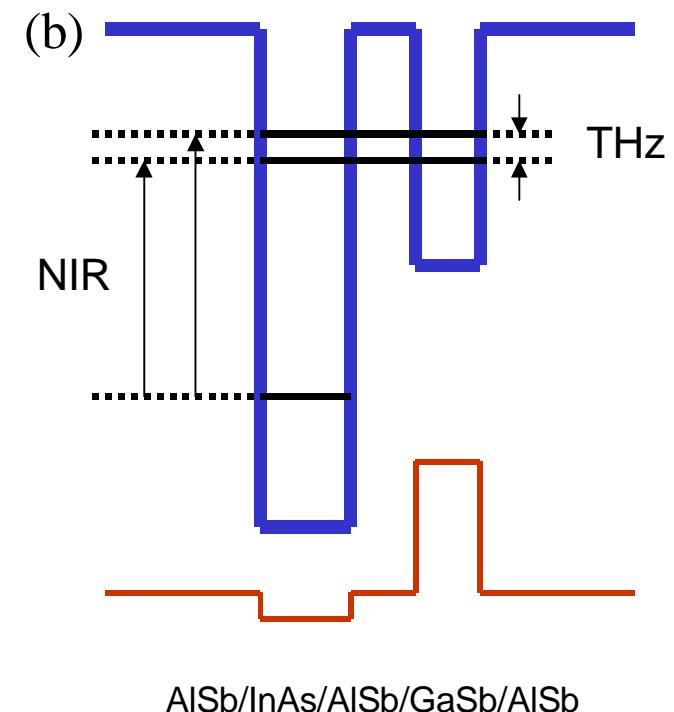
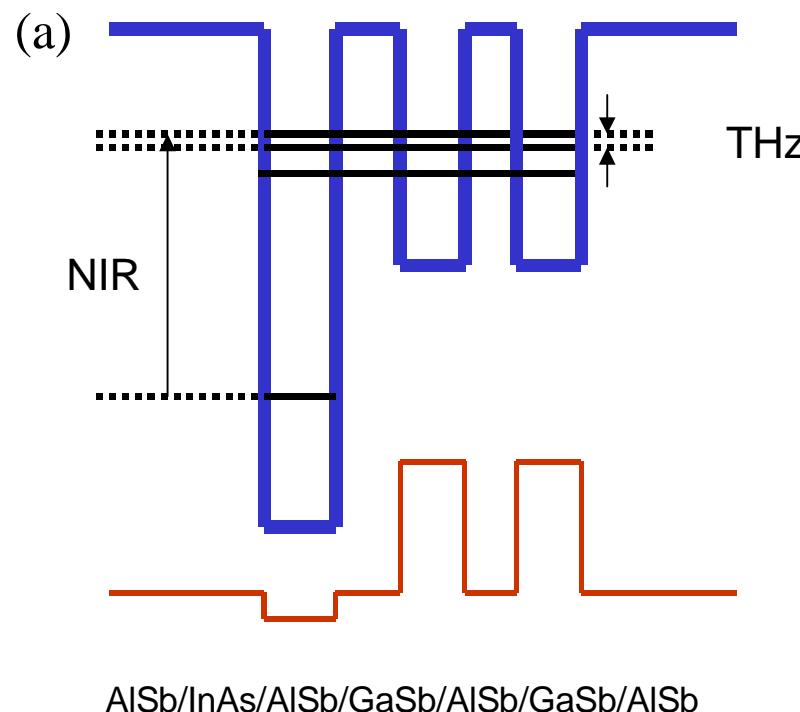
Diode-Laser Pumped Difference Frequency Generation (InGaAs/InP/AlAsSb QWs)



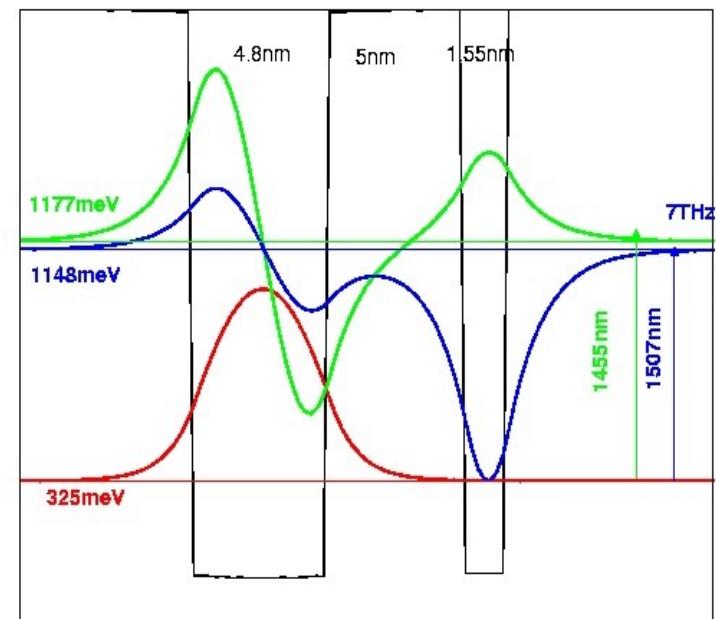
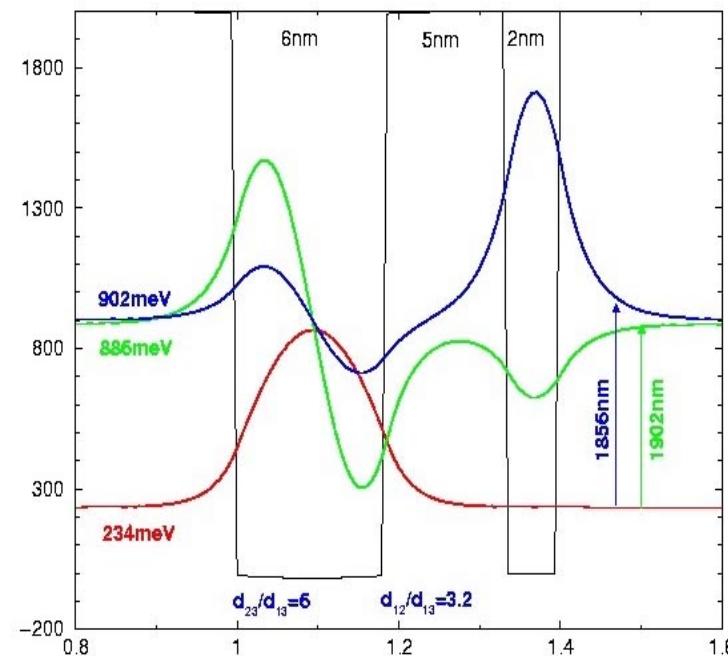
Liu and Ning, Nonlinear Optics, OSA Digest, 2000

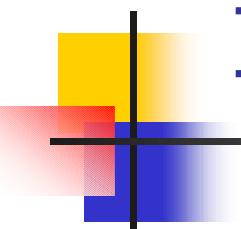


InAs/GaSb/AlSb Quantum Wells



InAs/AlSb Double QWS: DFG Scheme





InAs/AlSb Triple QWs: Laser Scheme

