Light emitting diodes using $In_xGa_{1-x}P$ quantum well structures for wound healing

Kaitlyn Parsons
ECE 498CB – Professor Bayram

Outline

- Motivation and background
- Simulation results
- Final Structure
- Summary

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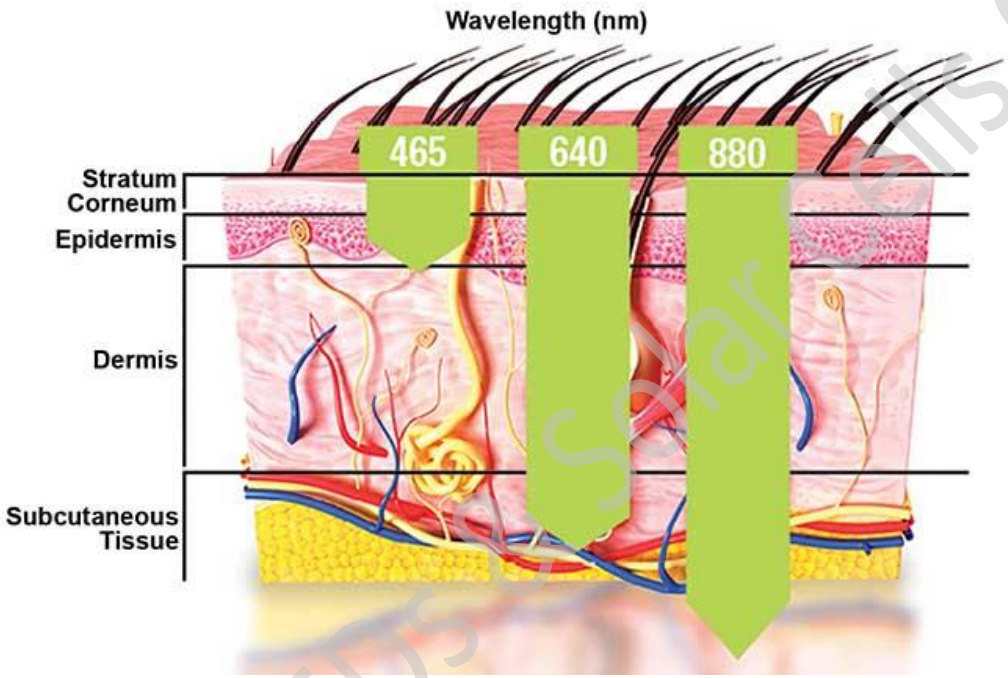
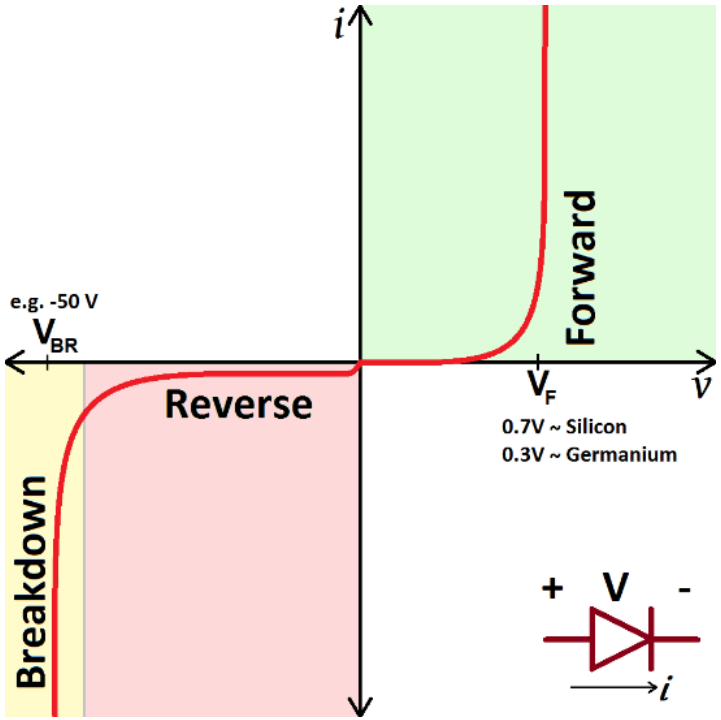
Motivation and background

- Light therapy used to treat skin wounds
  - Traditional methods ➔ thermal damage
- 610 – 650 nm wavelengths for difficult to heal wounds
- LEDs ➔ tunable emission
  - Forward biased p-n junction
  - low-cost, mobile, safe



BioPhotas (2015).



Sparkfun (2018).

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  - Indium composition in wells
  - Number of quantum wells
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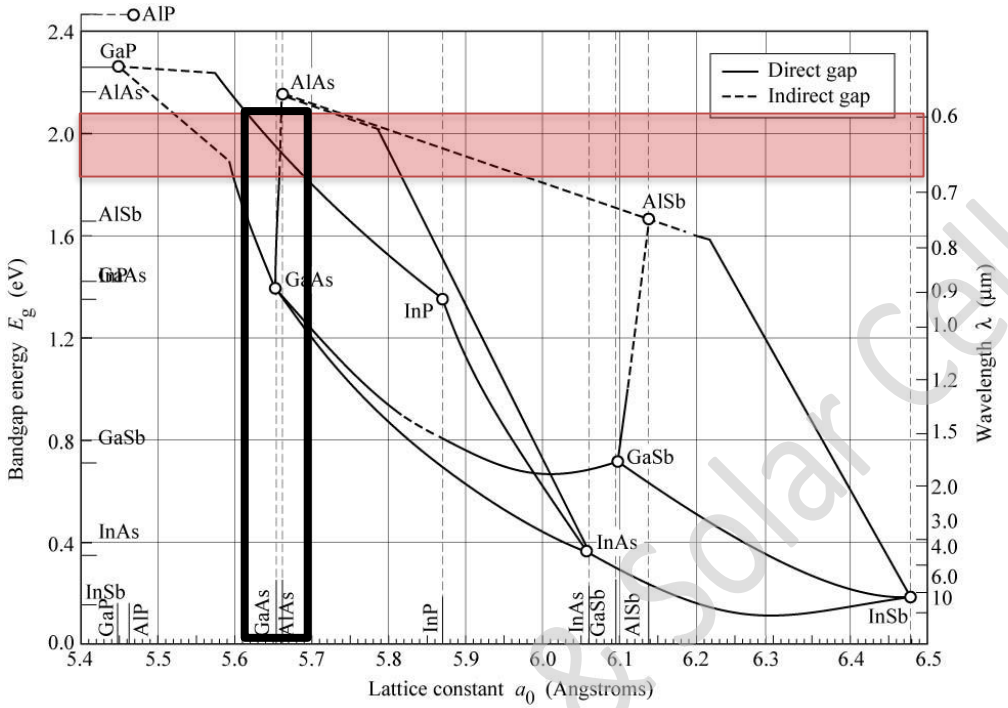
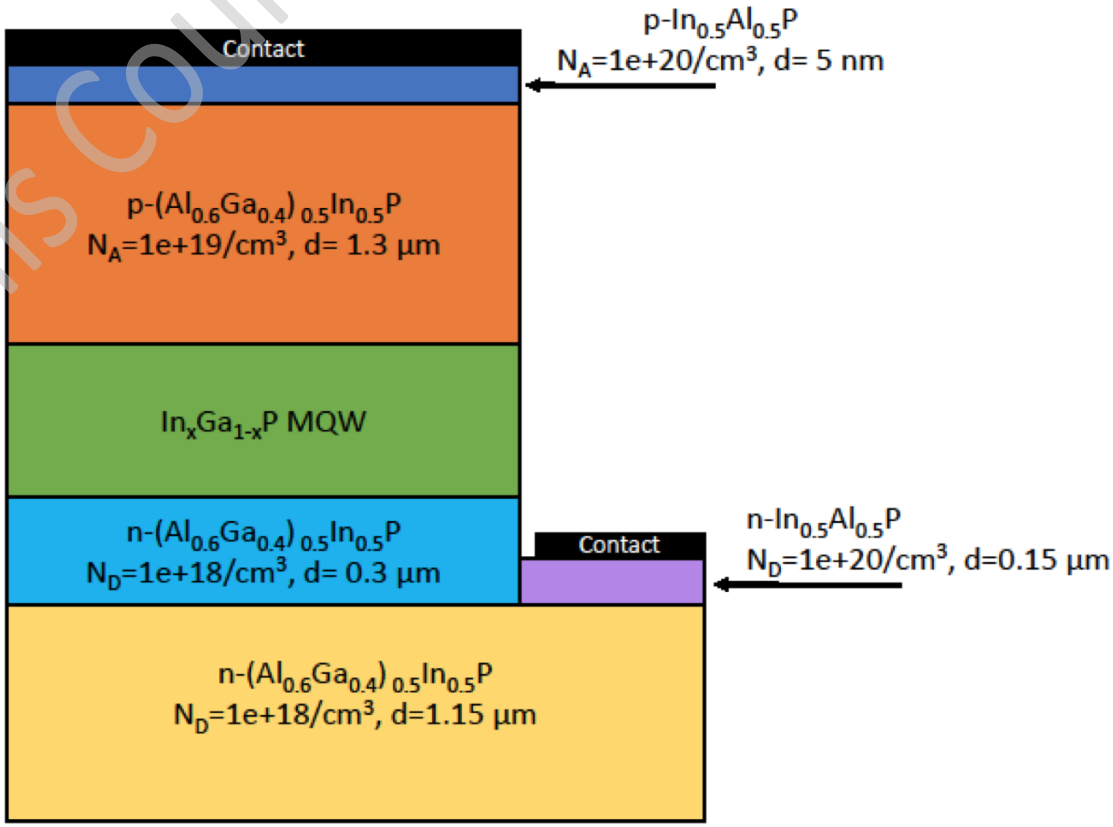
Lateral LED structure

- Target emission wavelength: 610 – 650 nm
  - $In_xGa_{1-x}P$ active region material
  - $(Al_{0.6}Ga_{0.4})_{0.5}In_{0.5}P$ barriers
- Wavelength tunability: well composition, width

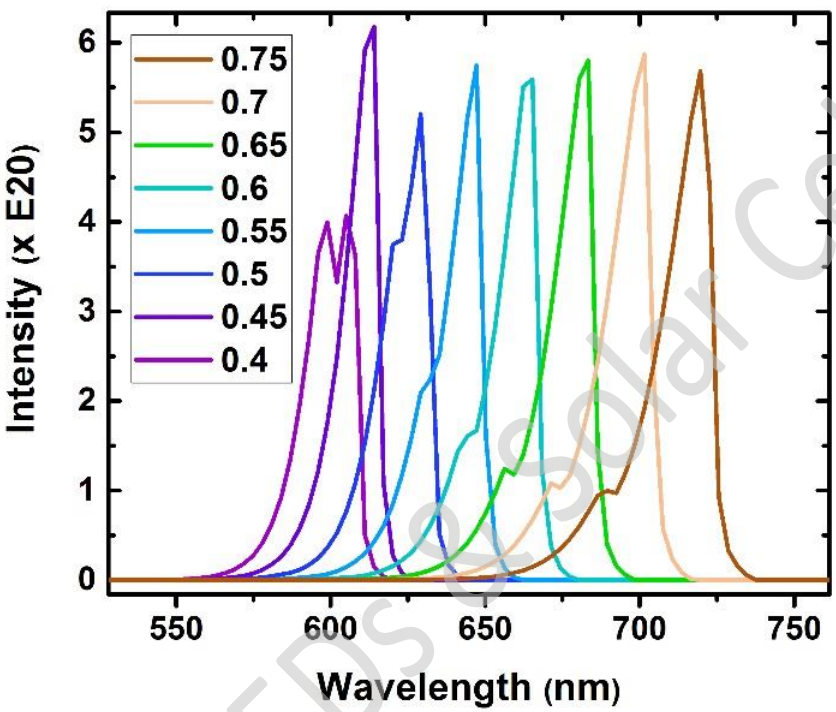


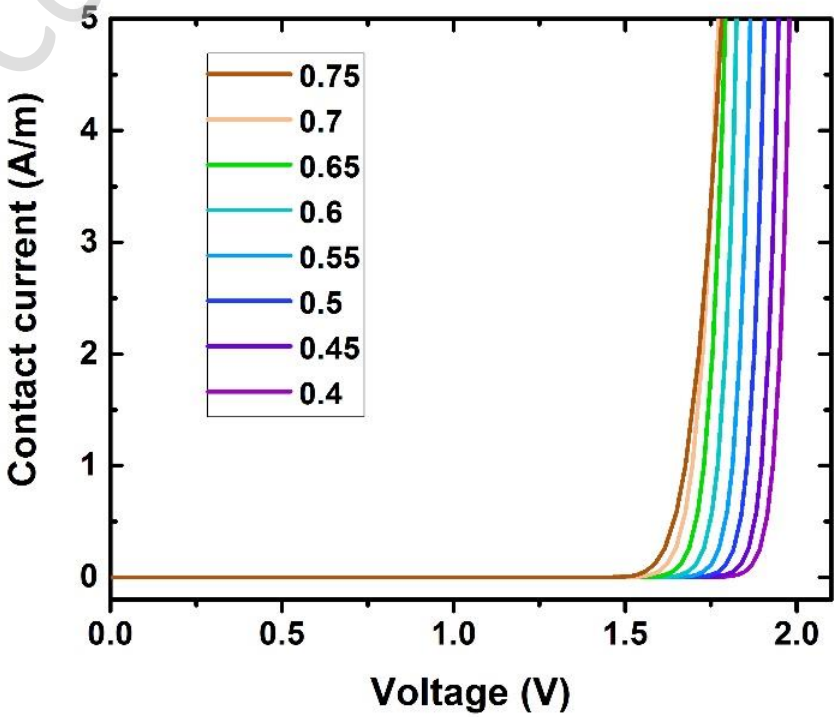


E. F. Schubert, *Light emitting diodes* (2006).

Indium composition

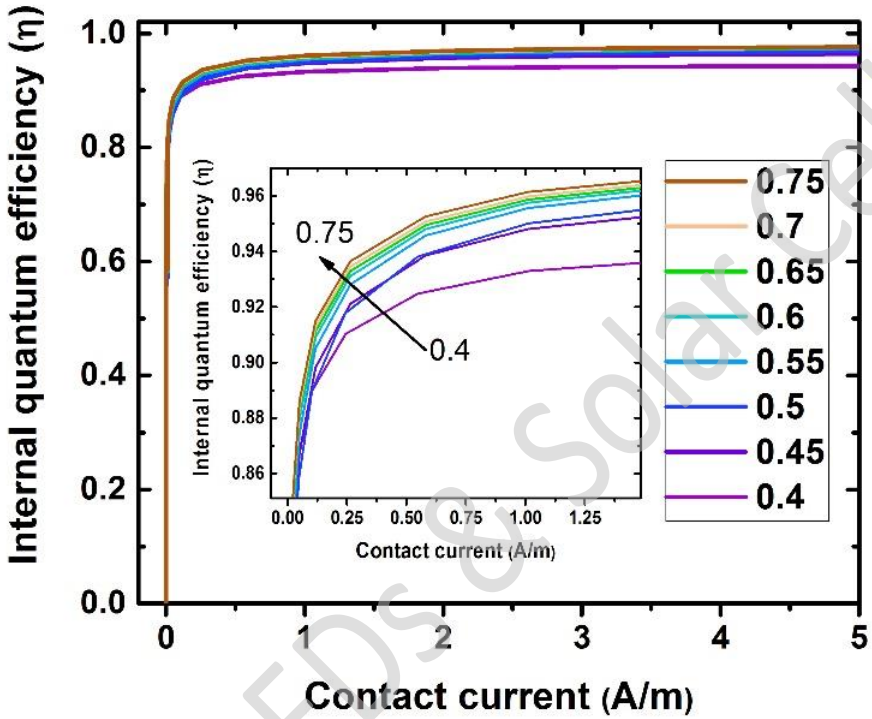
- Increasing In red-shifts spectrum
- Turn-on voltage decreases with increasing In

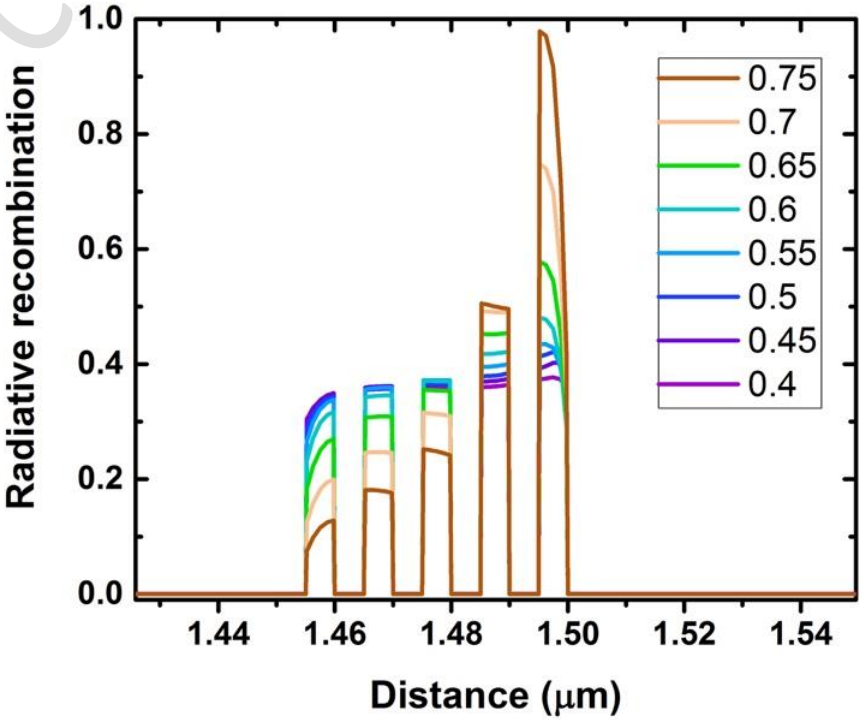




Indium composition

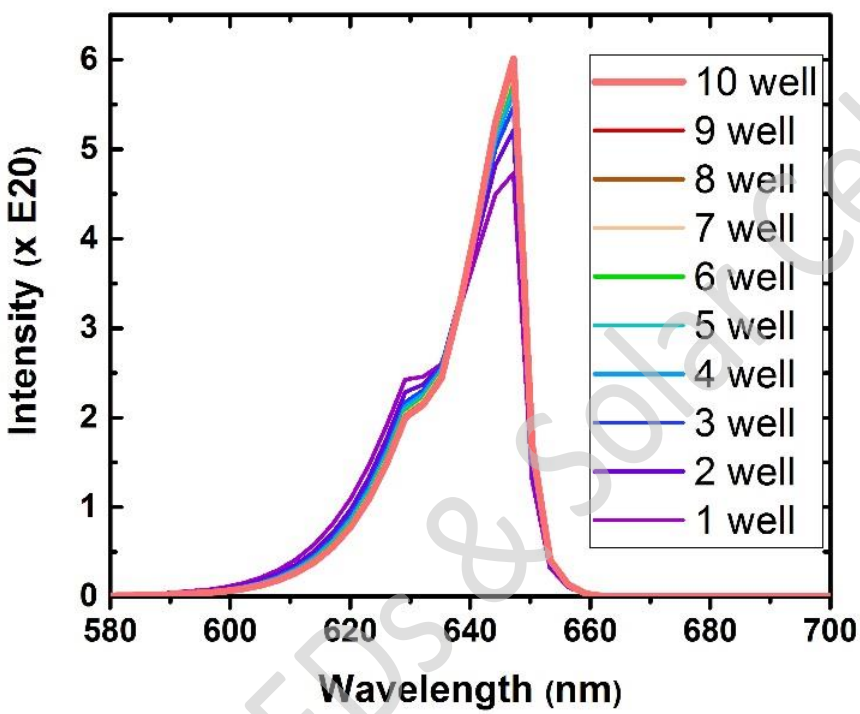
- Increasing In red-shifts spectrum
- Turn-on voltage decreases with increasing In
- Internal quantum efficiency increases with In
- Maximum radiative recombination increases with In

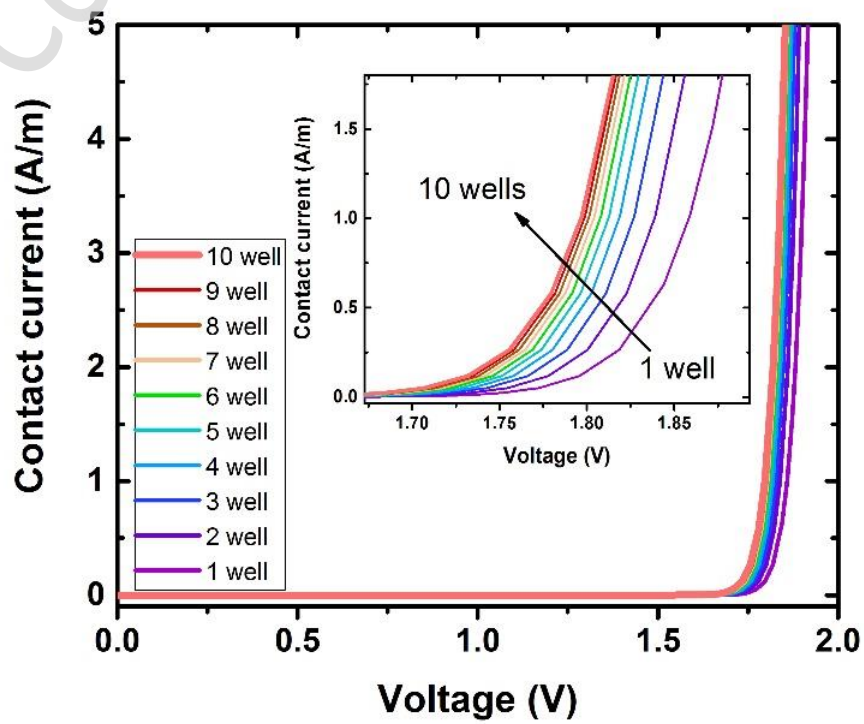




Number of quantum wells

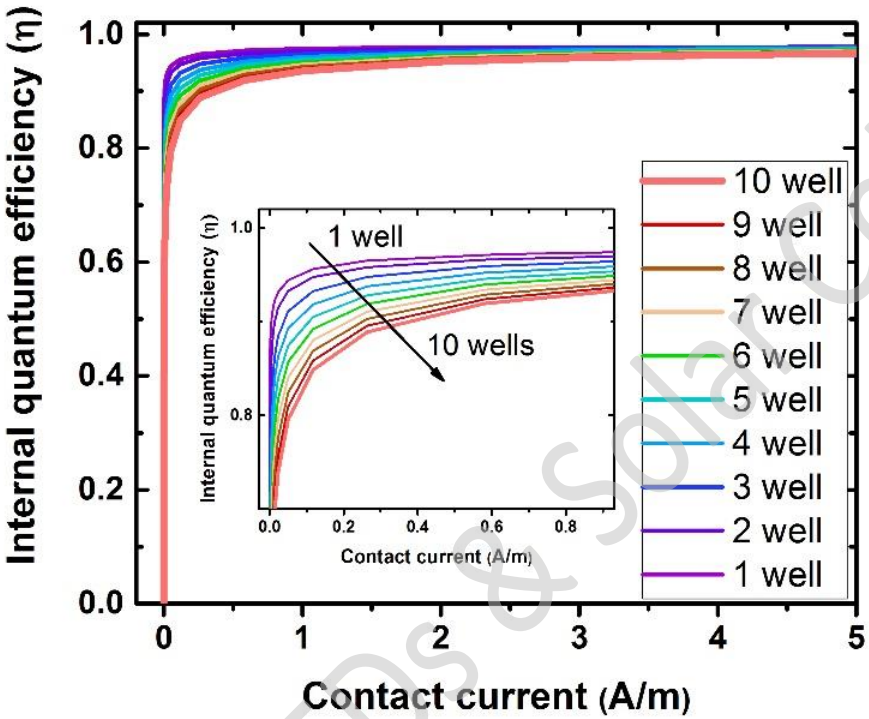
- Increasing number of wells increases emission intensity
- Turn-on voltage decreases with number of wells

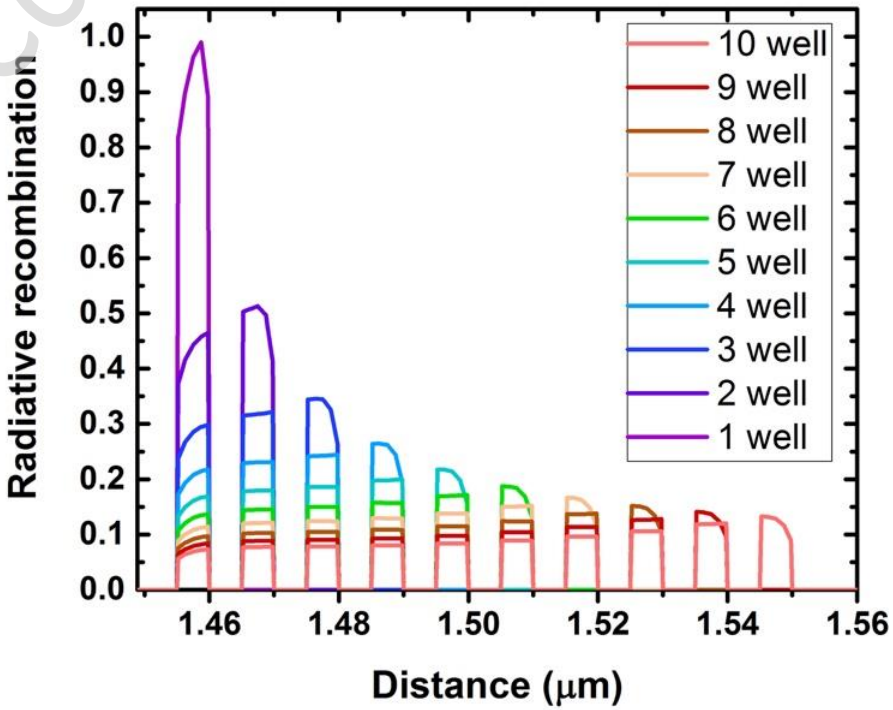




Number of quantum wells

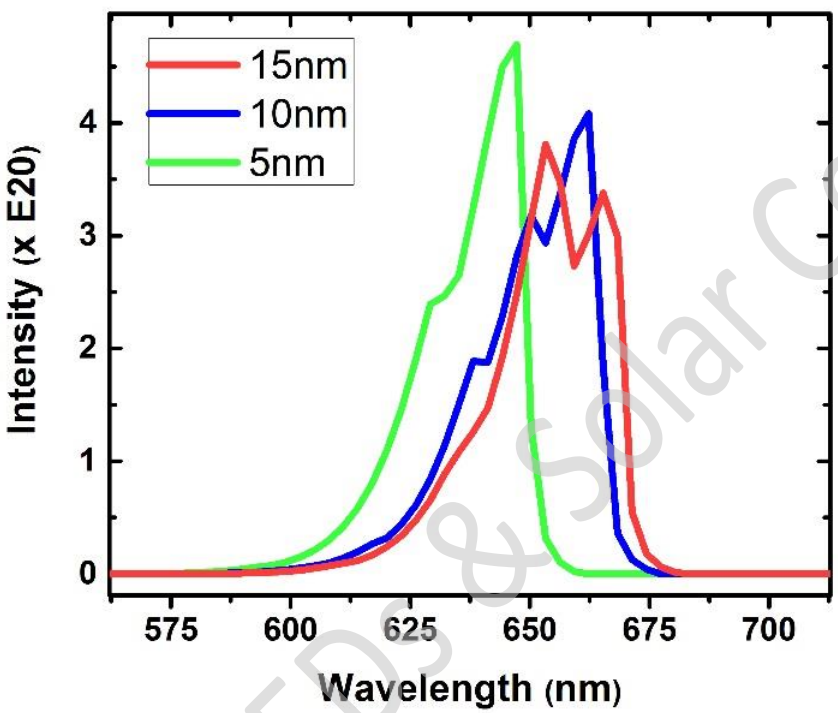
- Increasing number of wells increases emission intensity
- Turn-on voltage decreases with number of wells
- Decrease in internal quantum efficiency with more wells
- Total radiative recombination evenly distributed between wells

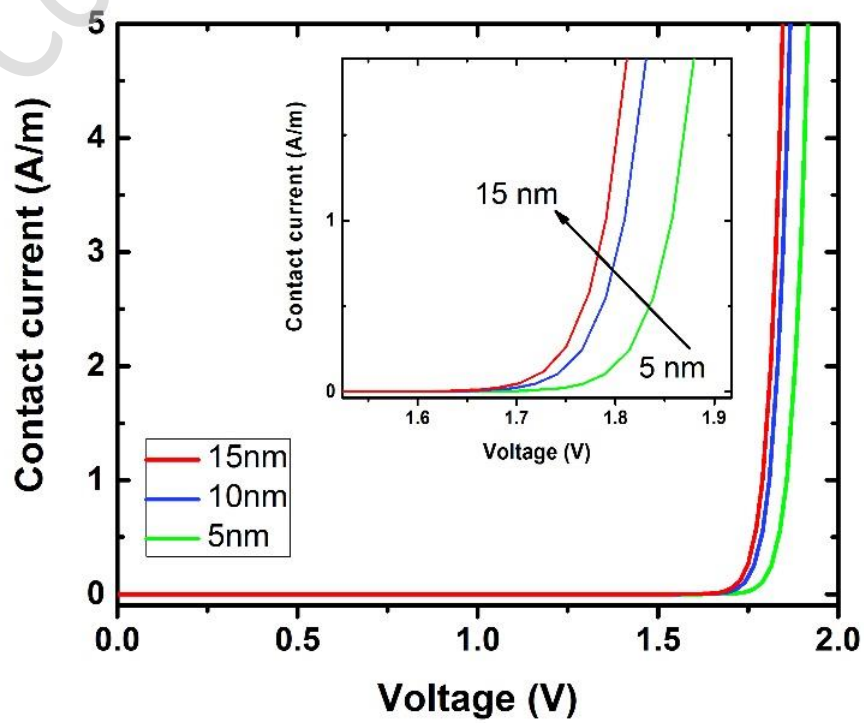




Well thickness

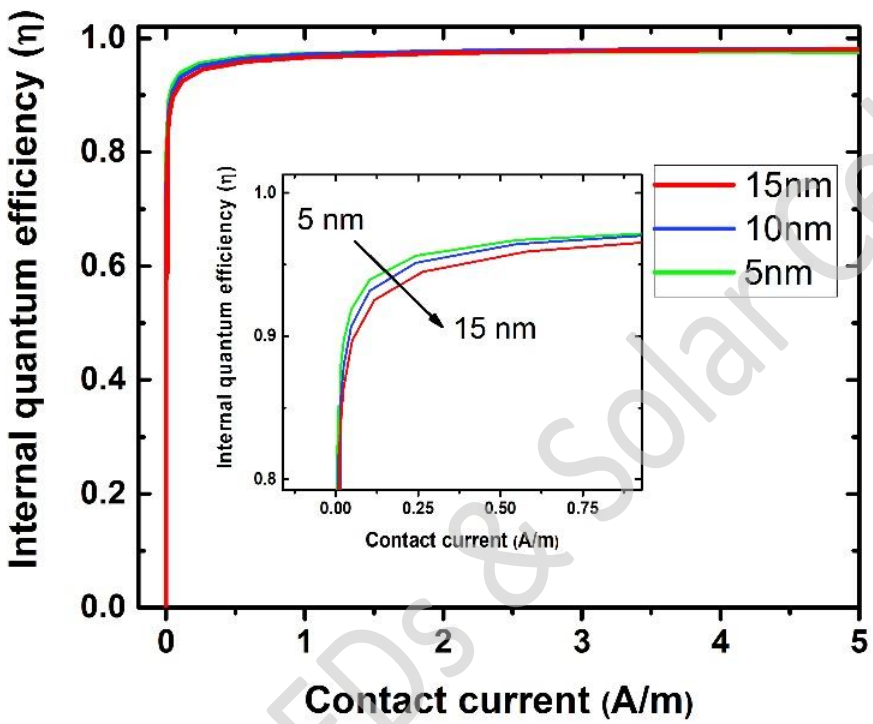
- Increasing well width red-shifts peak emission
- Turn-on voltage decreases with increasing width

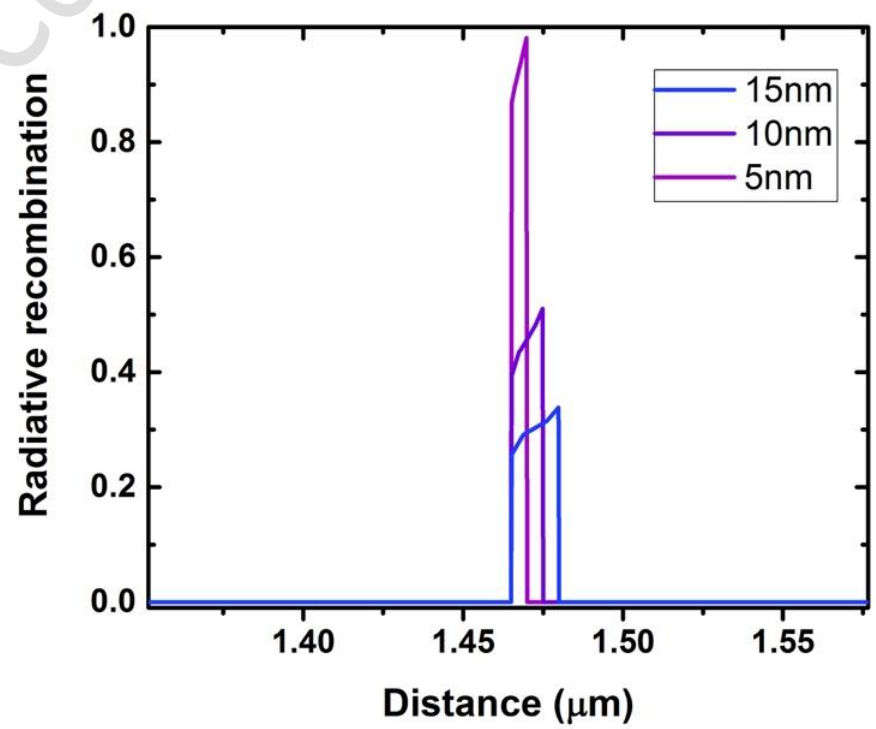




Well thickness

- Increasing well width red-shifts peak emission
- Turn-on voltage decreases with increasing width
- Internal quantum efficiency decreases with increasing width
- Radiative recombination decreases with increasing width





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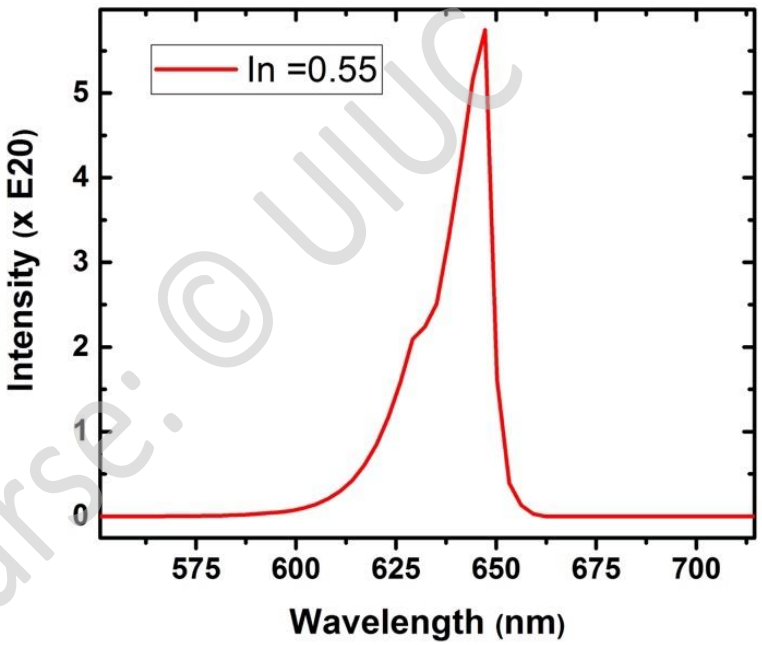
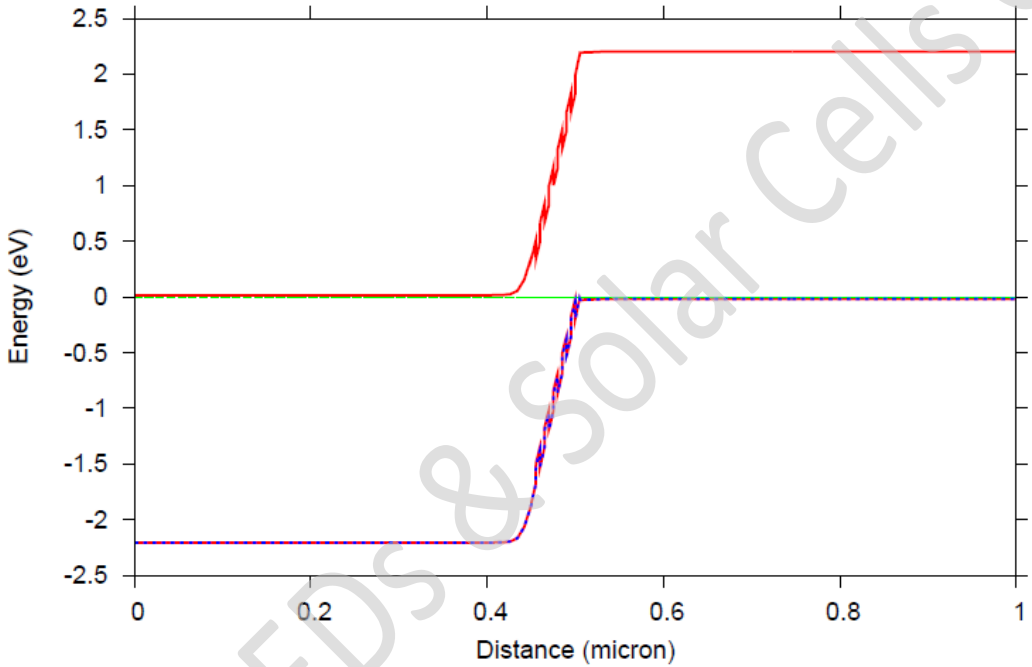
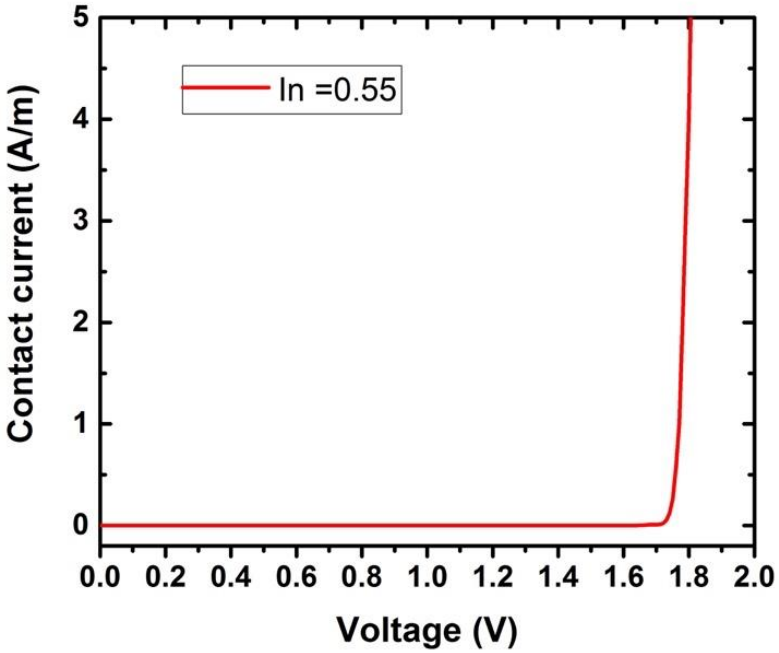
Final LED structure

- 5 quantum wells
- 5 nm thick wells and barrier
- $In_{0.55}Ga_{0.45}P$ composition







Final LED structure

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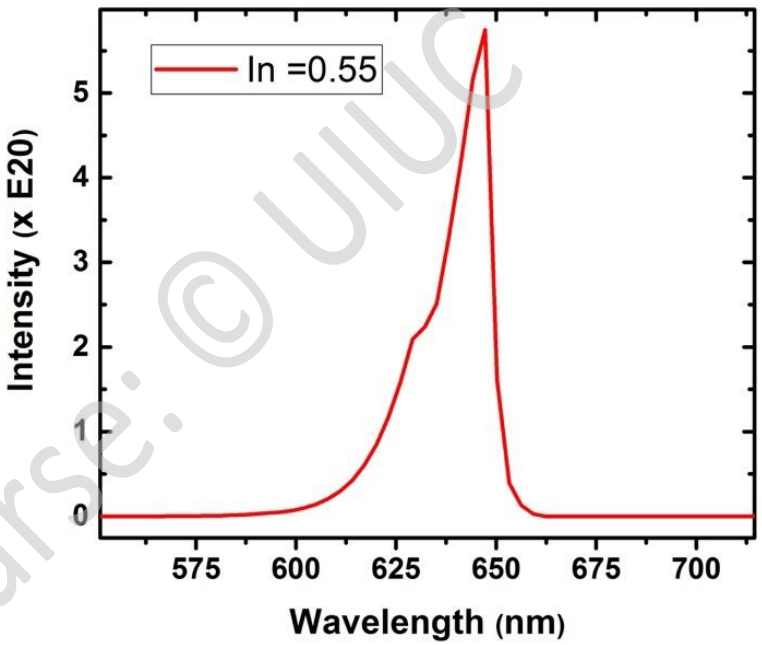
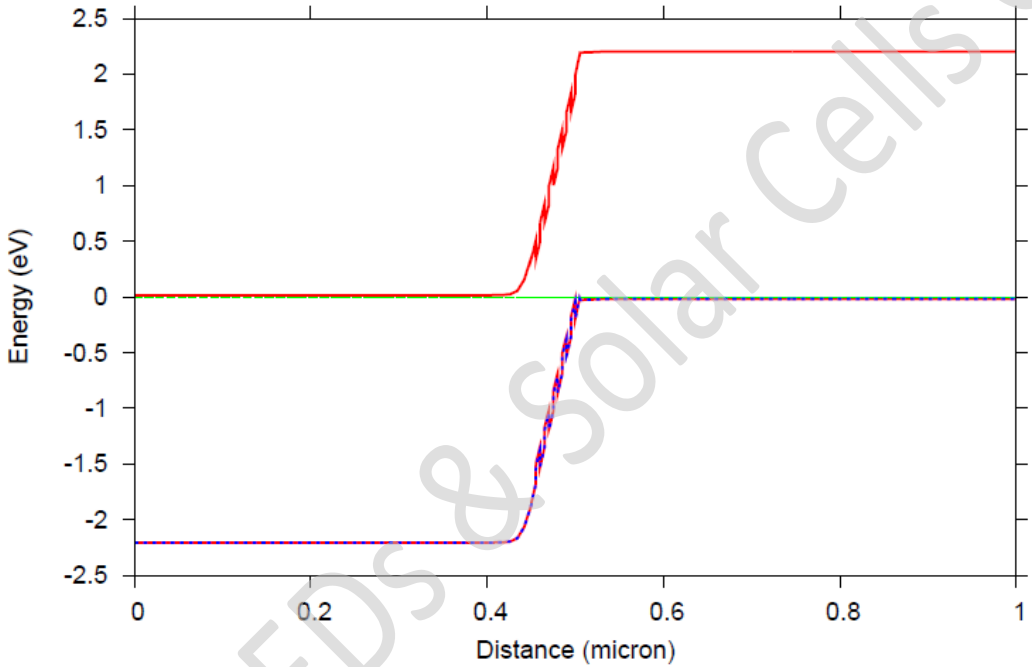
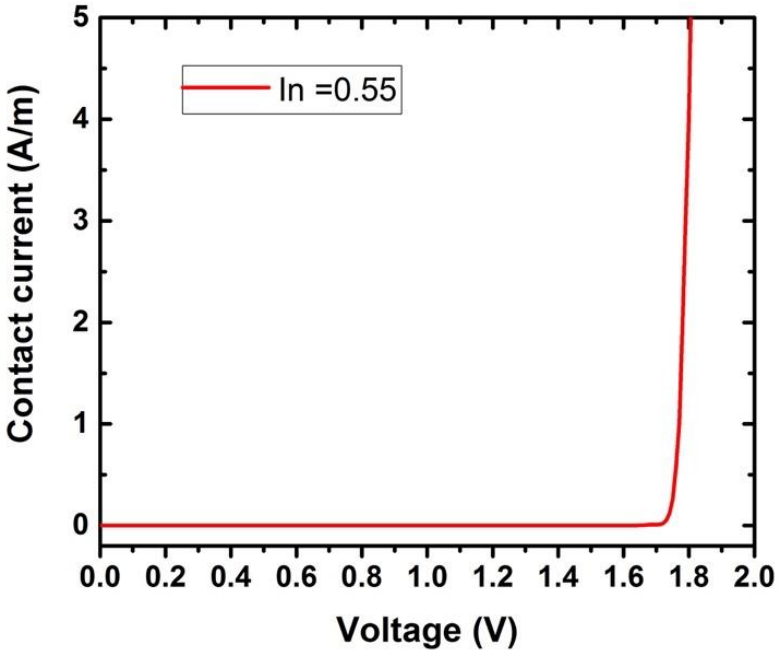
- 5 nm thick wells and barrier
- $In_{0.55}Ga_{0.45}P$ composition

- Peak emission = 647 nm
- Turn-on voltage = 1.8 V







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- 610 – 650 nm light required for difficult to heal wounds
- InGaP/(AlGa)InP multiple quantum well LED
- Composition and well width tunes emission wavelength
- 55% In, 5 nm well, 5 wells optimum for 647 nm emission

Thank you!