Electronics and Photonics Design Automation

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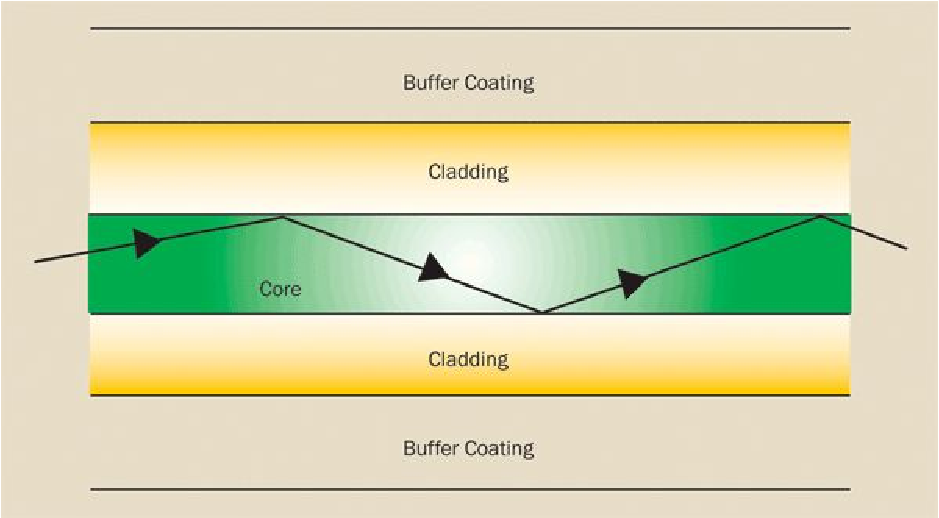
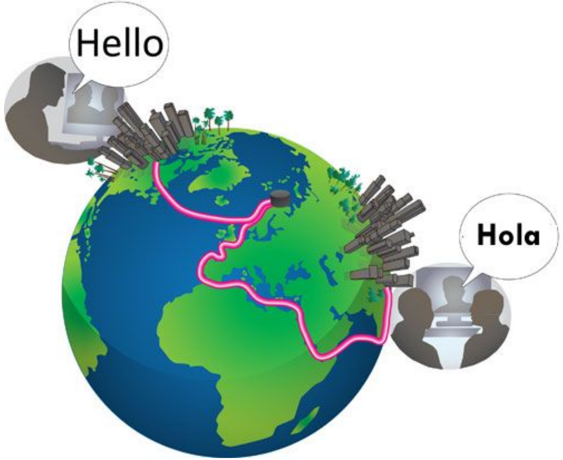
UCSB

CSEP

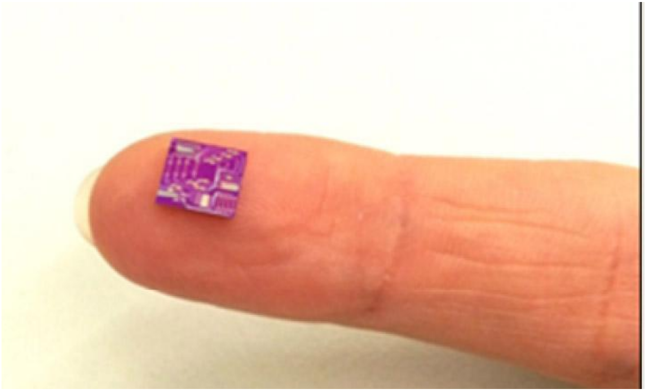
Opto-electronics In Our Society



High Efficiency - Low Energy Usage



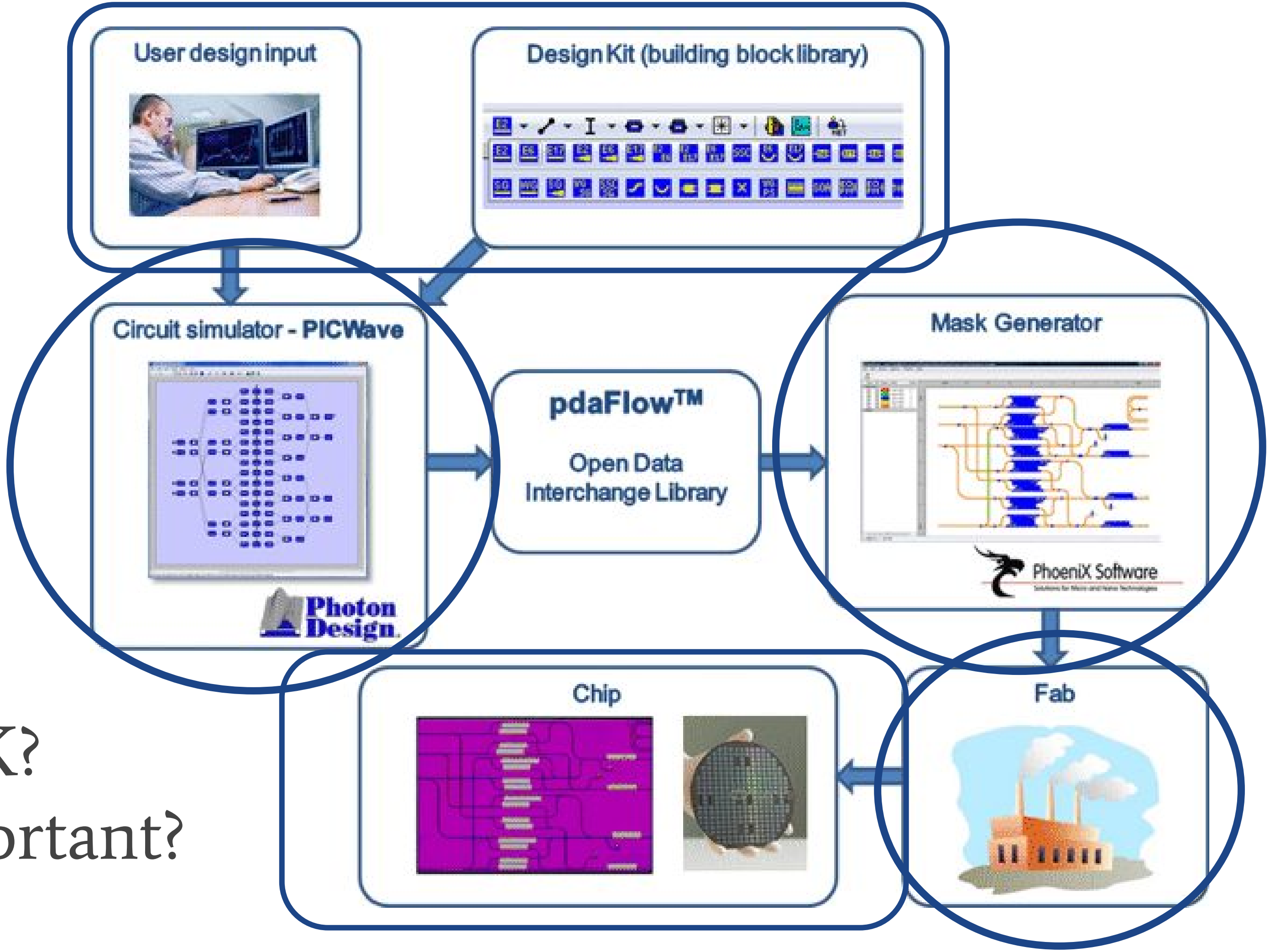
High-Speed Communication



Creating a PDK

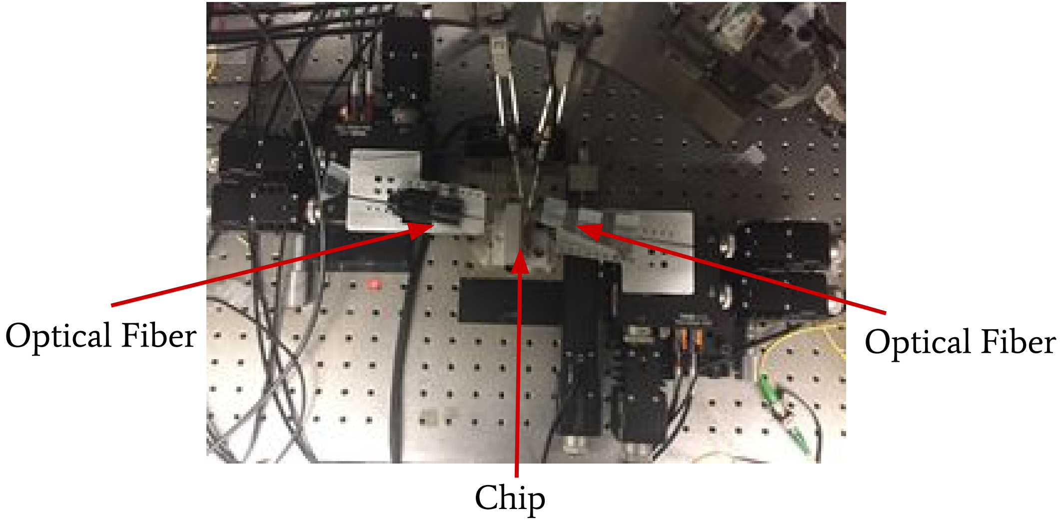
- Short term: developing and implementing algorithm for automated measurement to measure different optical devices

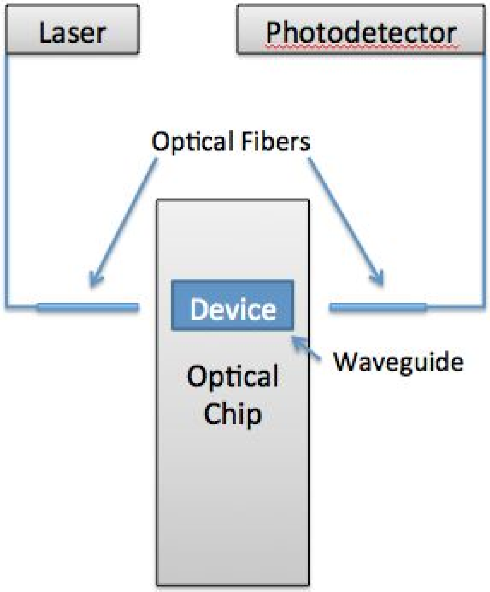
- Long term: develop PDK (process design kit) for UCSB clean room process to facilitate design and fabrication of photonic integrated circuit

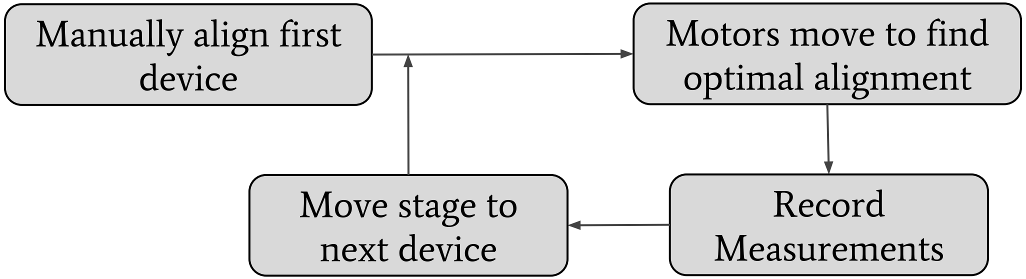


What is a PDK?
Why is it important?

Automated Alignment Algorithm

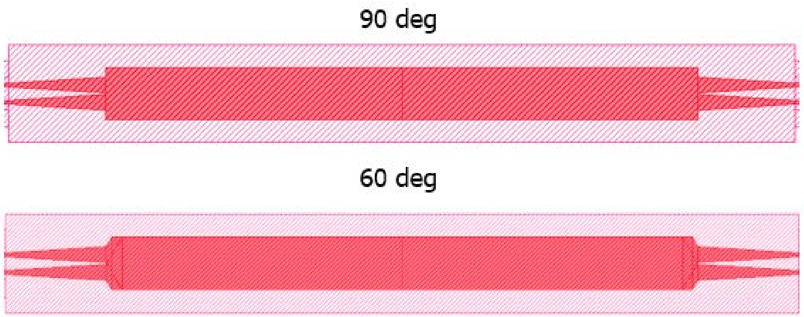






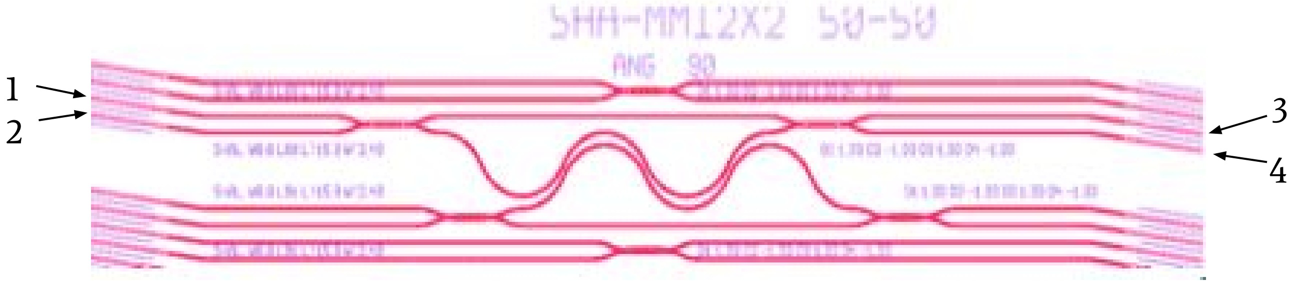
MATLAB

Multimode Interferometer 2x2 50-50

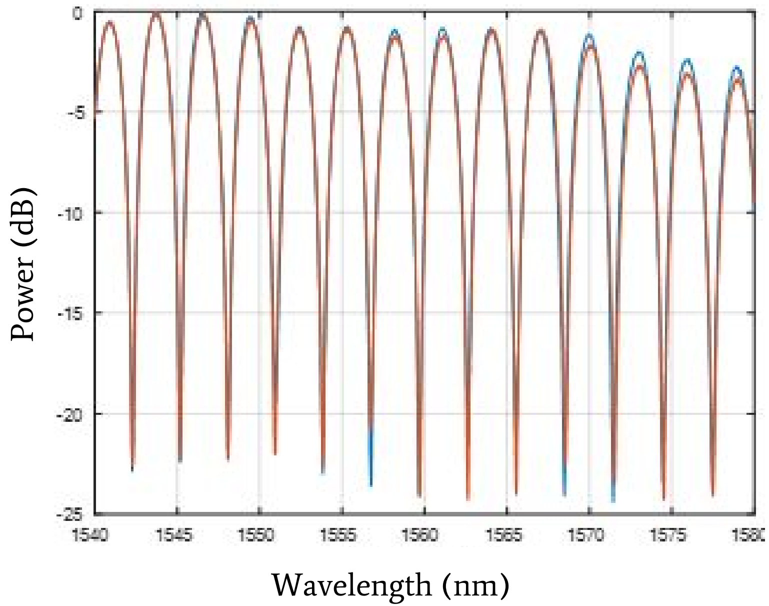


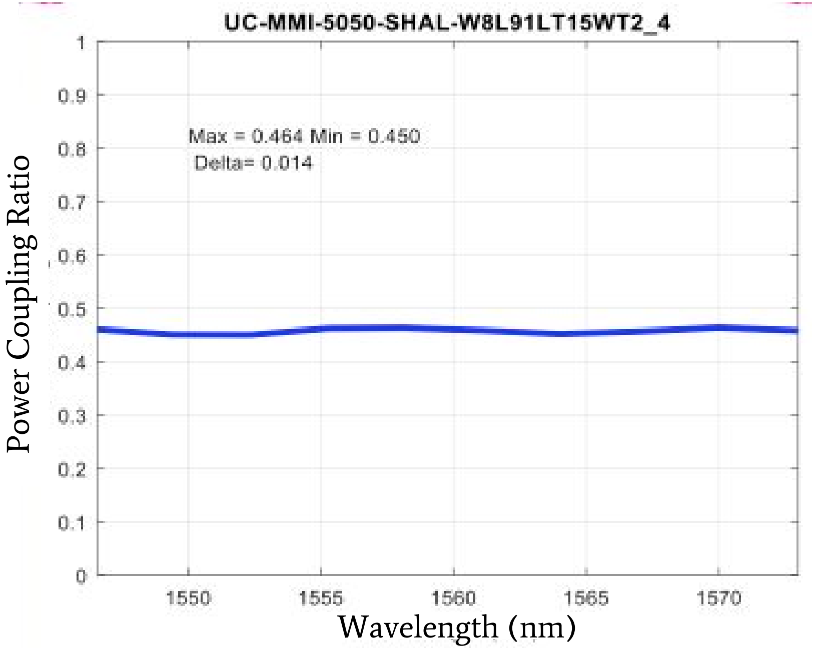
- Characterizing MMI in order to design the PDK
- Angle and Length of MMI determines power output
- Looking for splitting ratio of ~0.5 (50-50)

Shallow Etched MMI



Shallow etched MMI with 50/50 power splitting ratio



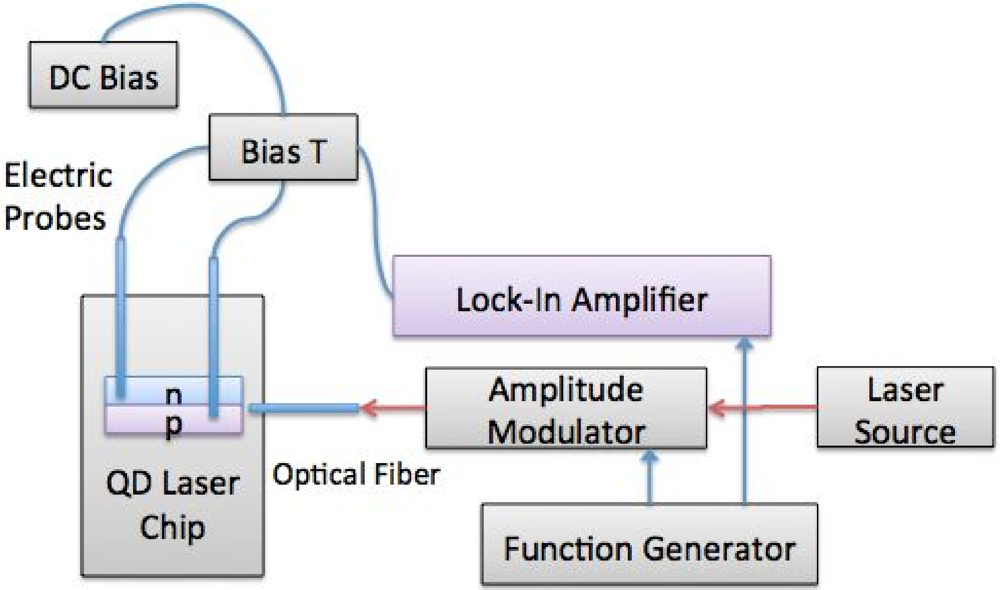


- Smaller length/width → optimal power coupling ratio
- No effect on ratio due to angle

$$\kappa = \sin^2\theta = \frac{\left(\frac{\sqrt{R_{13}}-(-1)^l}{\sqrt{R_{13}}+(-1)^l}\,\frac{\sqrt{R_{24}}+(-1)^m}{\sqrt{R_{24}}-(-1)^m}\right)^{1/2}}{1+\left(\frac{\sqrt{R_{13}}-(-1)^l}{\sqrt{R_{13}}+(-1)^l}\,\frac{\sqrt{R_{24}}+(-1)^m}{\sqrt{R_{24}}-(-1)^m}\right)^{1/2}} \quad (9.b)$$

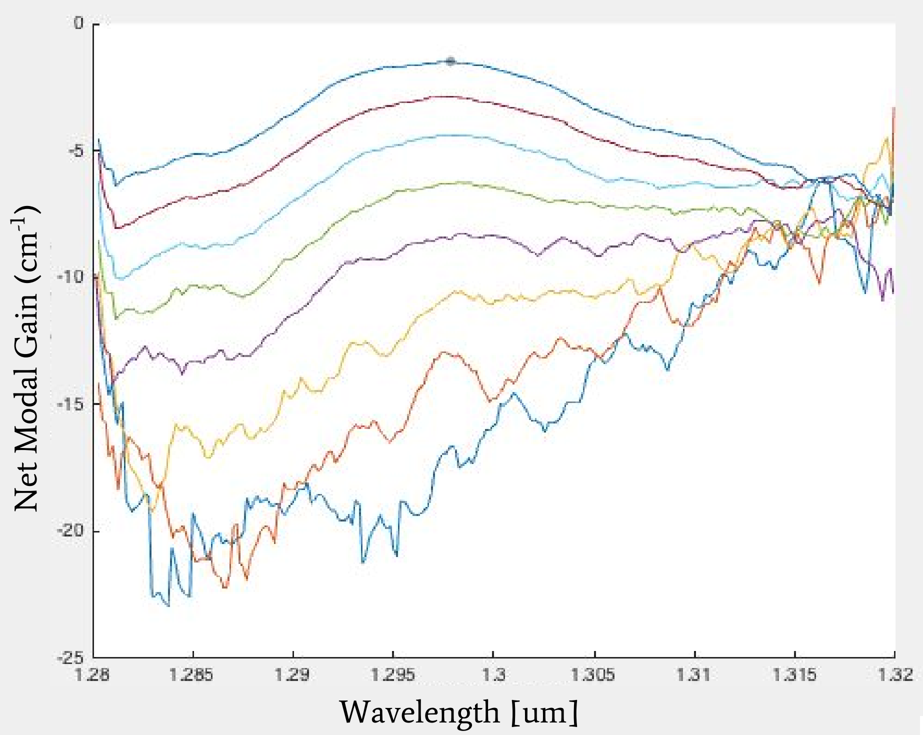
Minh et al, "A Robust Method for Characterization of Optical Waveguides and Couplers"

Quantum Dot Laser Setup

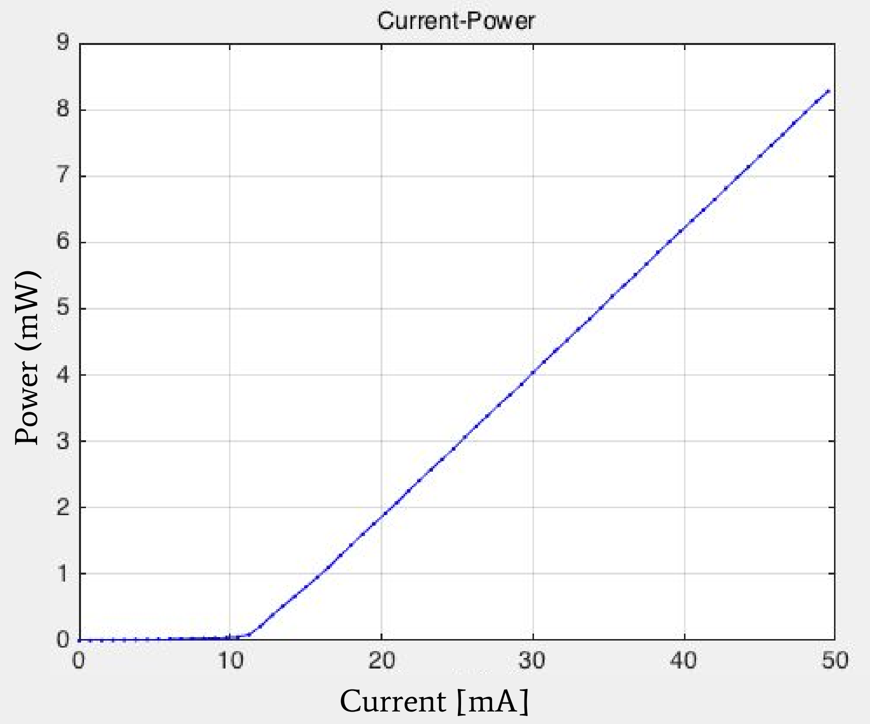


Lock-In Amplifier measures magnitude and phase of the RF signal detected from the probe pad of the QD laser

GaP/Si 5QD Layers 2.5um x 1250 um

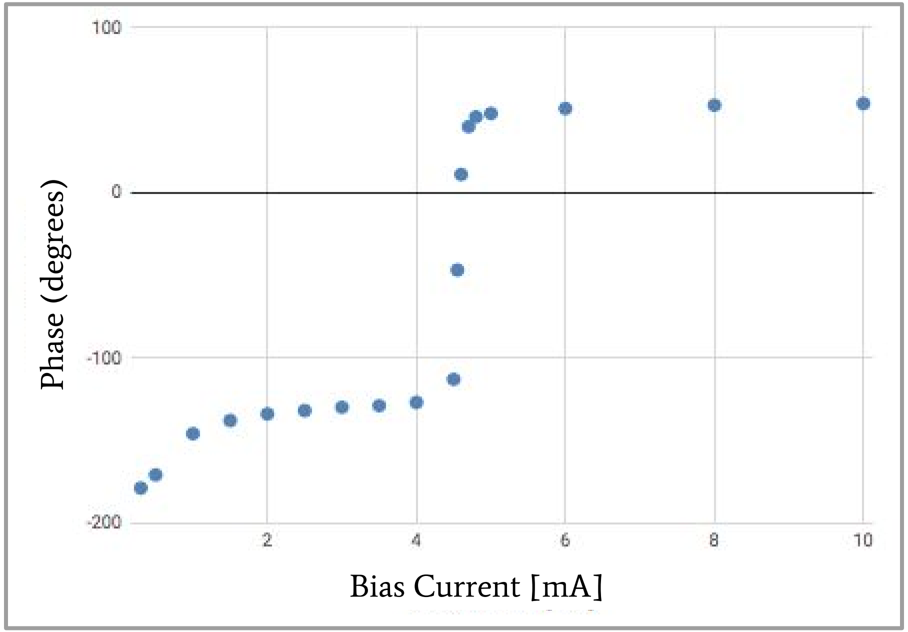


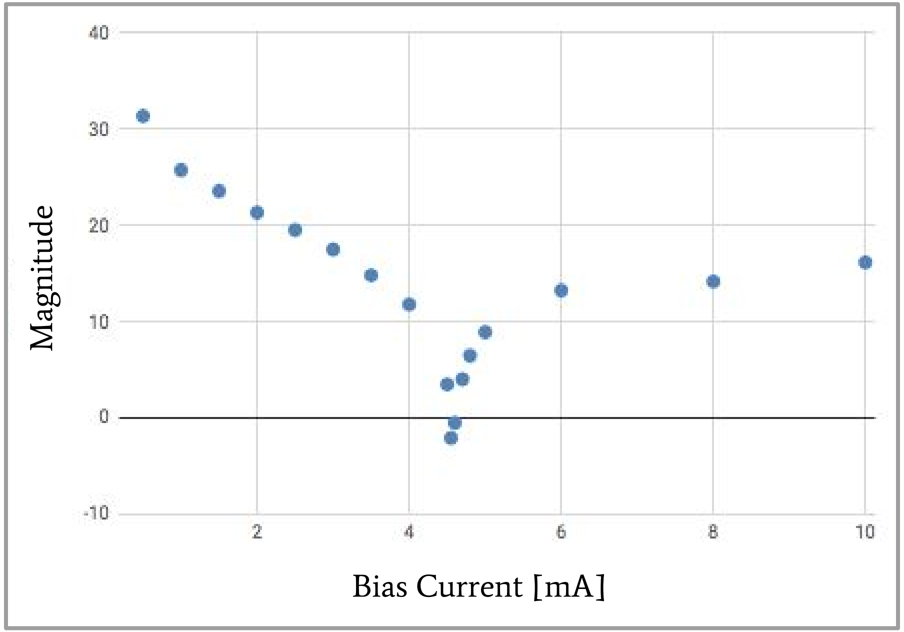
Max Gain: 1.3 um



Threshold Current: ~12mA

Transparency measurement result for GaP/Si 5-QD Layer Device

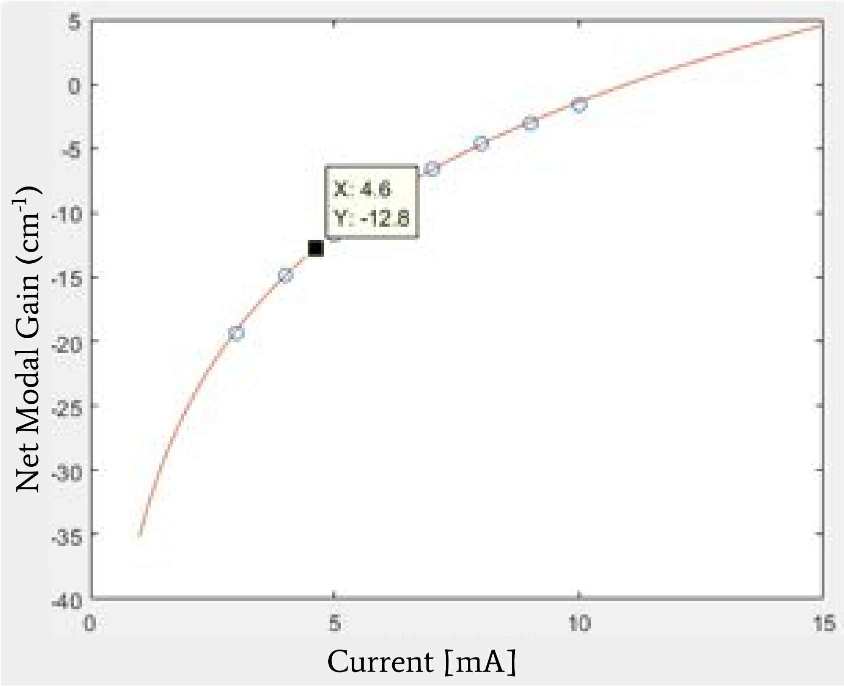




Transparency Current: point where phase goes from negative to positive ~4.6mA

Magnitude at transparency current must be at lowest point

Significance of Itr Measurement



Threshold Gain: ~12.8

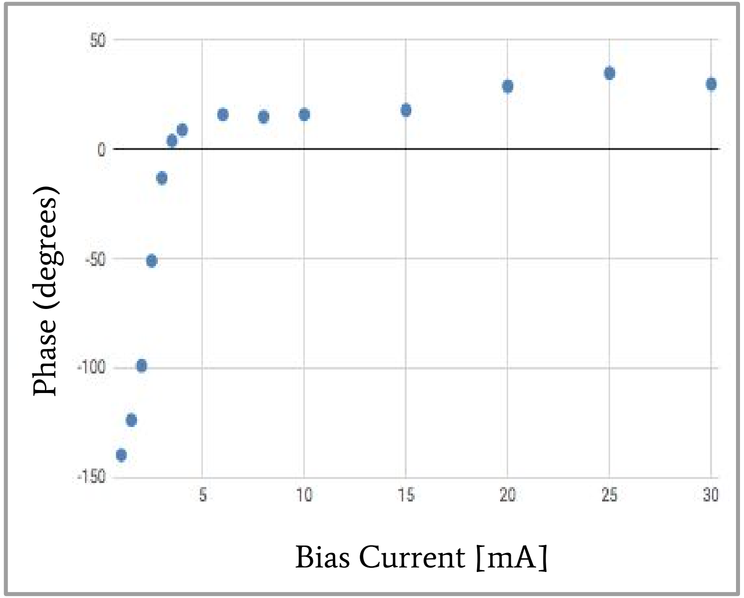
	width	length	Itr
I02	8	1250	9
I06	4	1250	5.5
I07	3.5	1250	4.7
I09	3	1250	4.6
I11	2.5	1250	4.25

	Ith	Ith prediction
I02	24.7	28.02
I06	26.9	27.84
I07	12.4	11.88
I09	10.96	11.00
I11	10.11	11.02

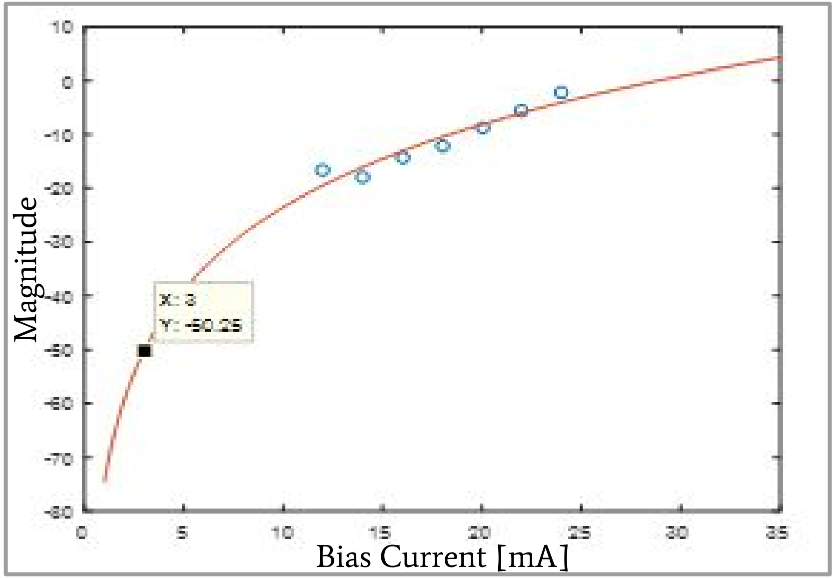
Smaller Width → Smaller transparency current → Smaller threshold current

Additional Observations

Early gain saturation → gain curve deviates from logarithmic shape



Transparency Current: ~3mA



Predicted by logarithmic model > 10mA Transparency Current. Actual: ~3mA

Summary

- MMI
  - Smaller length/width of MMI give more accurate coupling ratio value
- Quantum Dot Laser
  - Accurate measurement of Itr is obtained. Reliable laser behavior model can be constructed based on such measurement results.
- Process Design Kit
  - Enough measurements to characterize the MMI's. The device behavior for the MMI and QD laser can be modeled in the PDK.

Future Plans

- Continue testing and improving automated test setup algorithm
- Expanding the measurement capability to other devices
- Refining the device design based on gathered data
- Developing compact behavior models for the measured devices for the PDK