SBCC
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UCSB

Software Development for High Speed Characterization of Photonic Integrated Circuits

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INSET
Internships in Nanosystems Science, Engineering and Technology

LASOR

MTO DARPA MicroSystems Technology Office

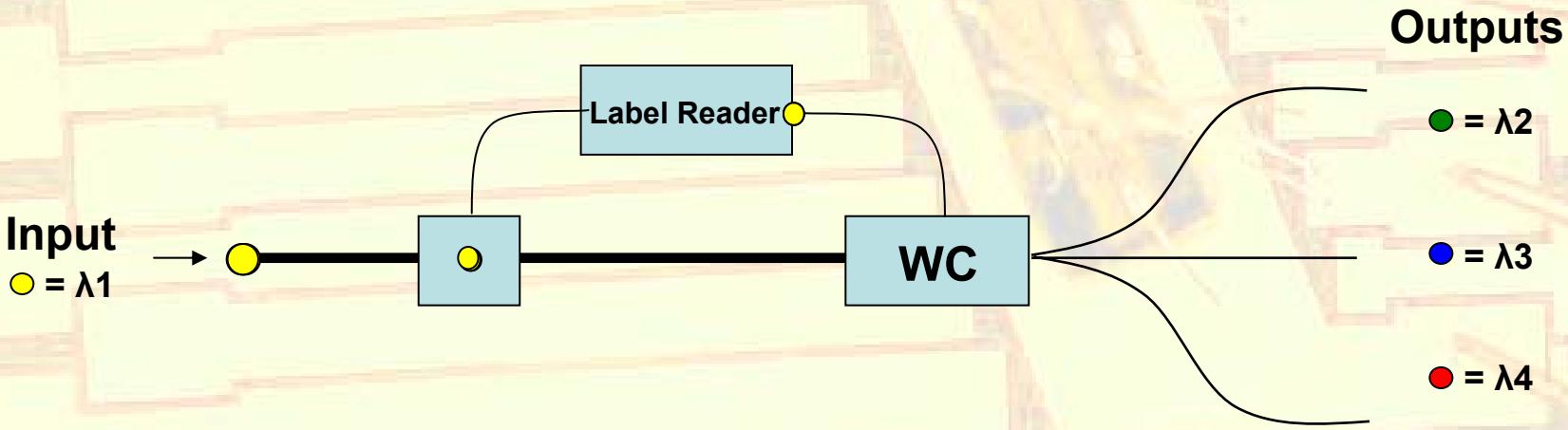
CNSI

The BIG Picture

- **Optical Fiber Communications**
  - **Networking systems**
  - **Optical Switching/Routing**
  - **Increase Bandwidth**
  - **Decrease Power Usage**
  - **Dense Wavelength-Division Multiplexing**
- **Label Switched Optical Router (LASOR)**
- **Funding**
  - **The Defense Advanced Research Projects Agency (DARPA)**

LASOR

- Current Technology
  - OEO (Optical-Electronic-Optical)
  - 1.2 Tbps Routers
    - *(CRS-1 Cisco Systems 2007)*
- What's To Come
  - All-Optical
  - Wavelength Switching
  - > 100Tbps Routers



Photonic Integrated Circuit (PIC) Characterization

- **Current testing**
  - One component at a time
  - Incomplete data acquisition
- **Keithley 4500**
  - Up to 36 source/measure channels
  - Multiple components at a time
  - Automated
  - External Equipment Connectivity
- **High Speed Characterization Software**
  - Improve implementation
  - Improve design

Multiple optical components on a single chip

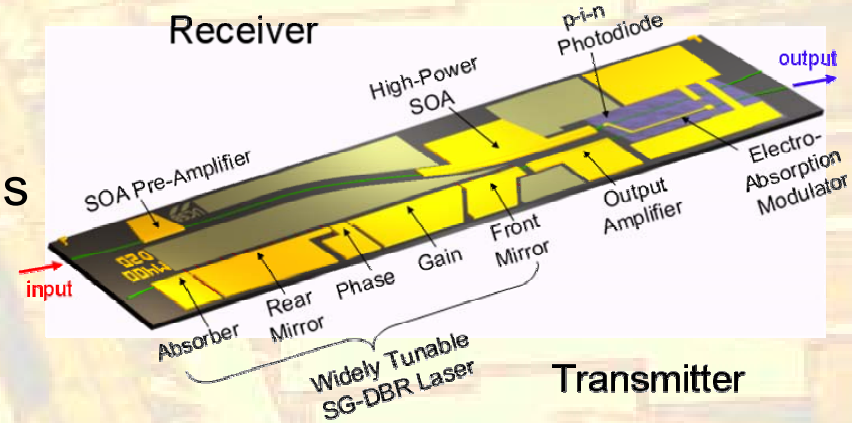
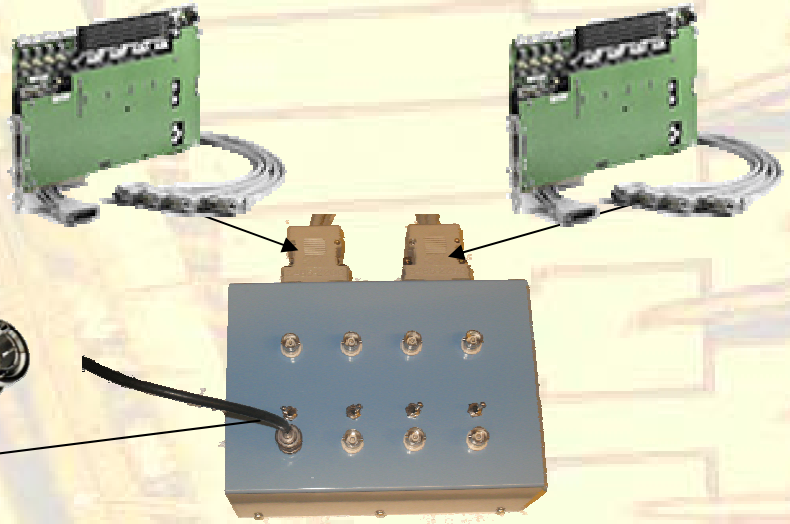
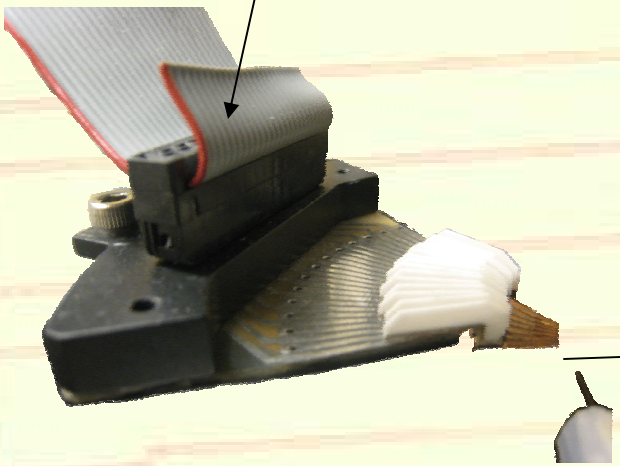
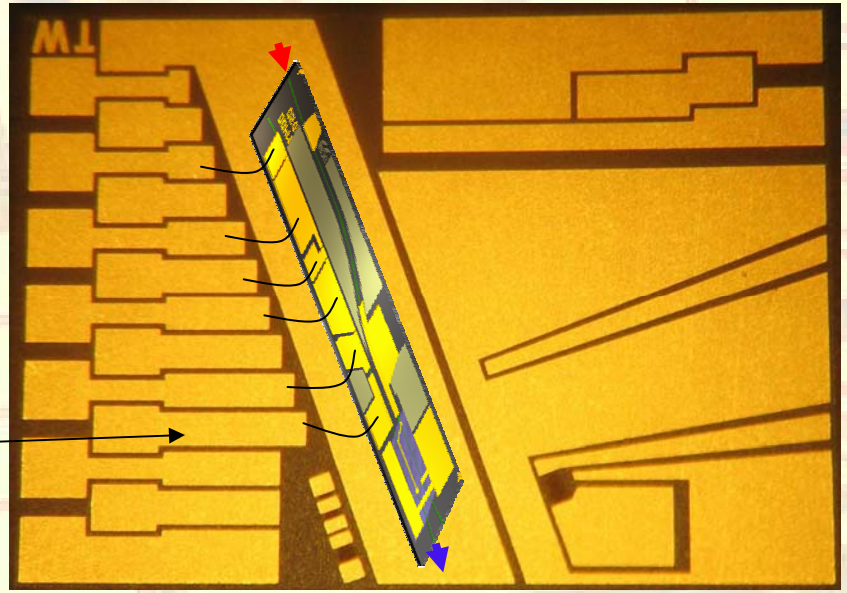


*Figure courtesy of Matt Dummer

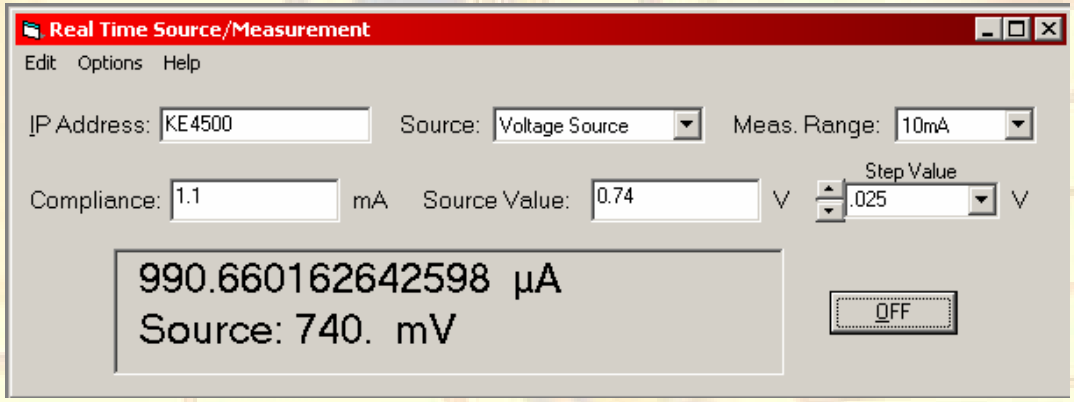
Modular Test System





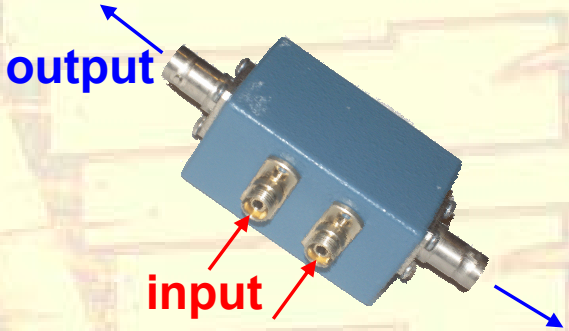


Software Development Goals



- **User Friendly Interface**
  - Easy to learn
  - Less likely to input incorrect data
- **More Functionality**
  - Provides voltage (V) and current (I) sources
  - V and I compliance
  - Active real time measurements
  - Remotely controls Keithley 4500
  - External equipment integration
  - Simultaneously sweep multiple sources
  - Graphing capabilities

Equipment Integration

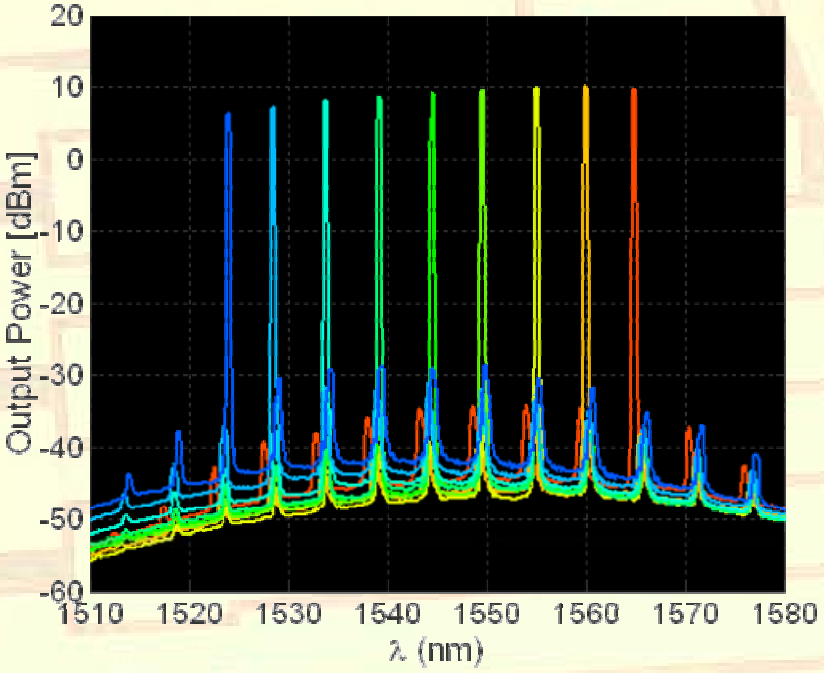


- **Photodiode**
  - Measure optical output power
- **General Purpose Interface Bus (GPIB) Compatibility**
  - Optical Spectrum Analyzer (OSA)
  - Polarization Controller
  - Temperature Controller
  - Optical Attenuator

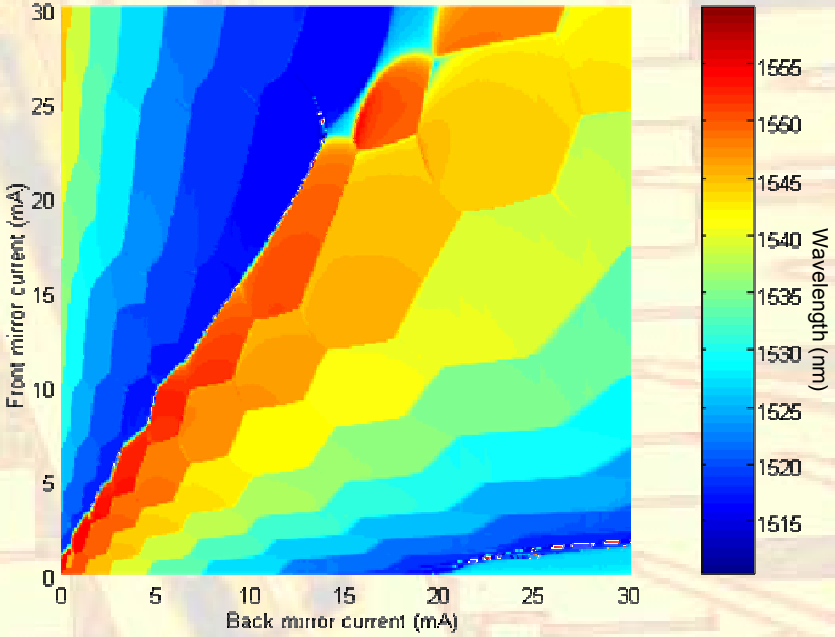
Graphing Capabilities

Types of Graphs I want to Generate With my Program

SGDBR Laser Spectrum



Multidimensional Tuning Map



**Data courtesy of Matt Dummer and Leif Johansson*

Conclusion

- **Modular Testing of PICs**
  - Developed & implemented software
  - Control up to 36 circuit elements simultaneously
  - Allows for real time monitoring of PIC performance
  - Sweeps multiple channels to acquire large arrays of data
- **Future Goals**
  - Develop all-purpose test environment
  - Produce Multidimensional Tuning Maps

Acknowledgements

My Family and Wife

Dr. Nick Arnold

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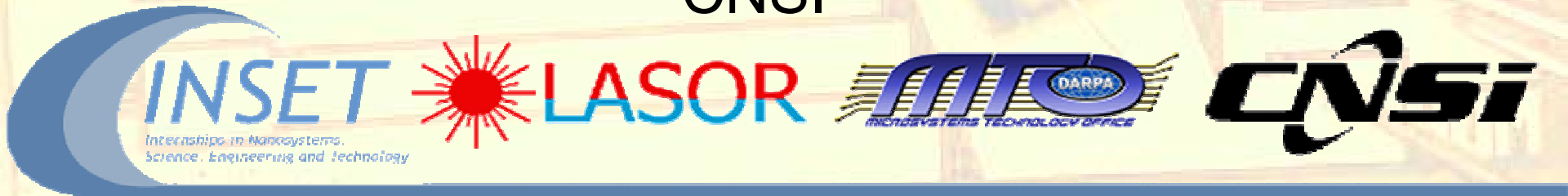
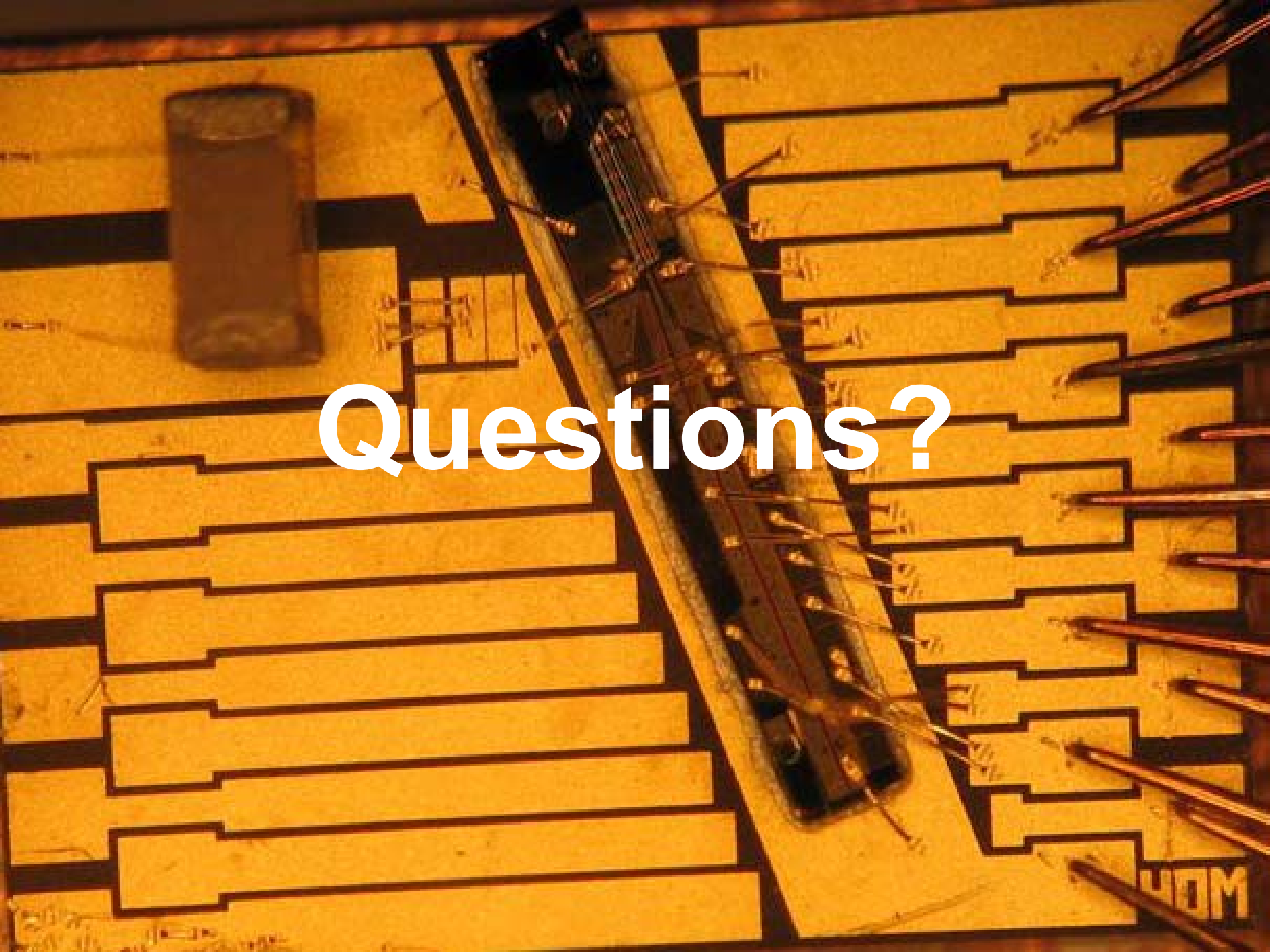
Matt Dummer

Dr. Larry Coldrens Group

INSET

CNSI

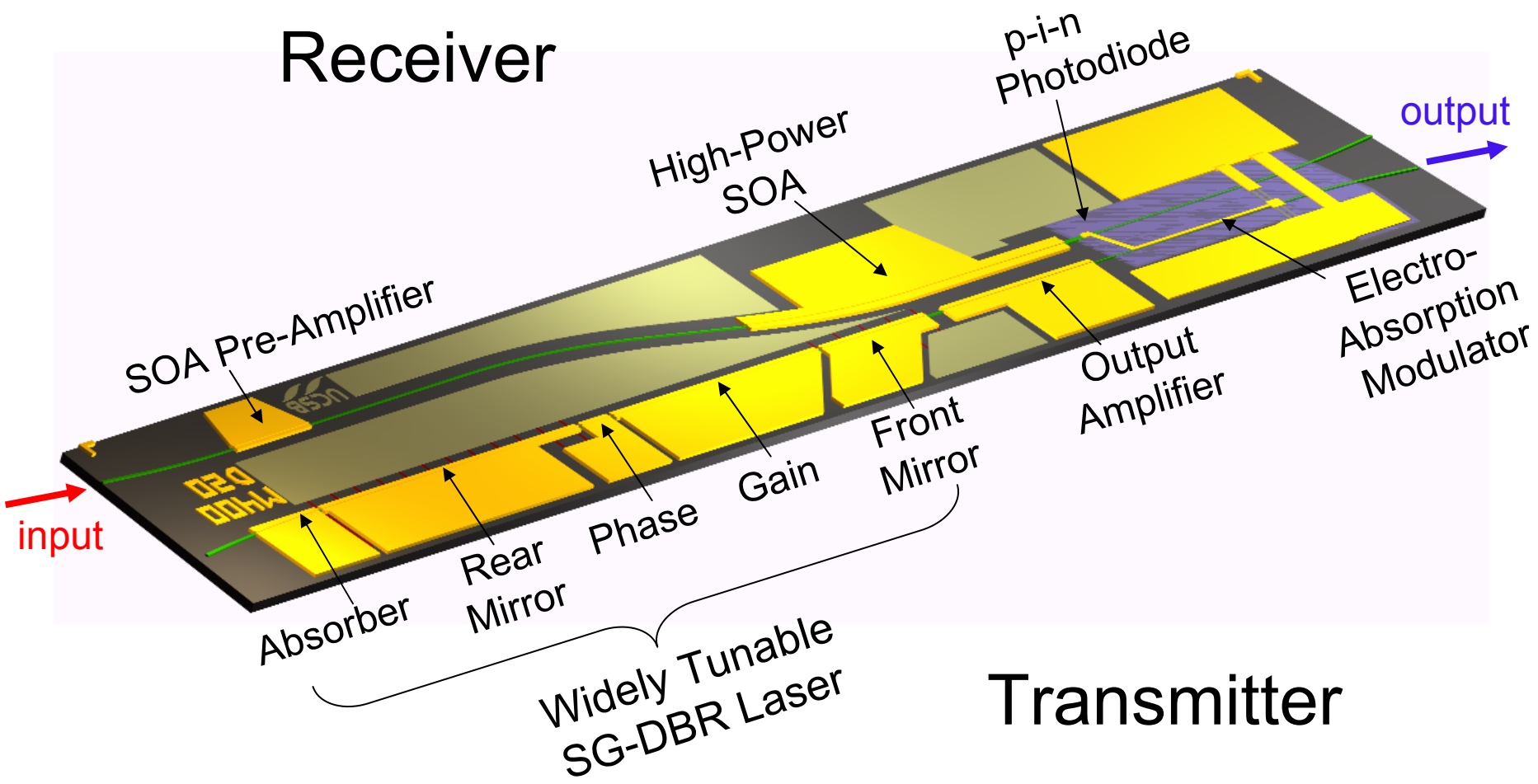



Questions?

Examples of Measurements

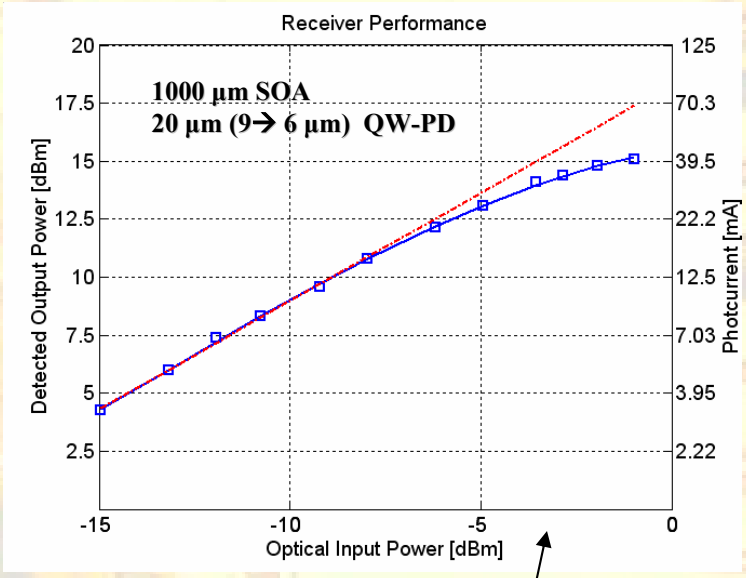
Utilizing the Keithley 4500

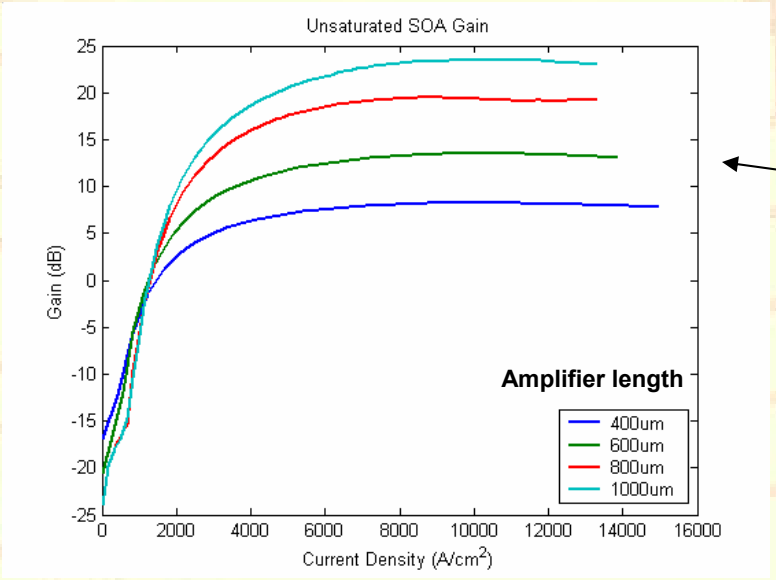
Widely Tunable Wavelength Converter

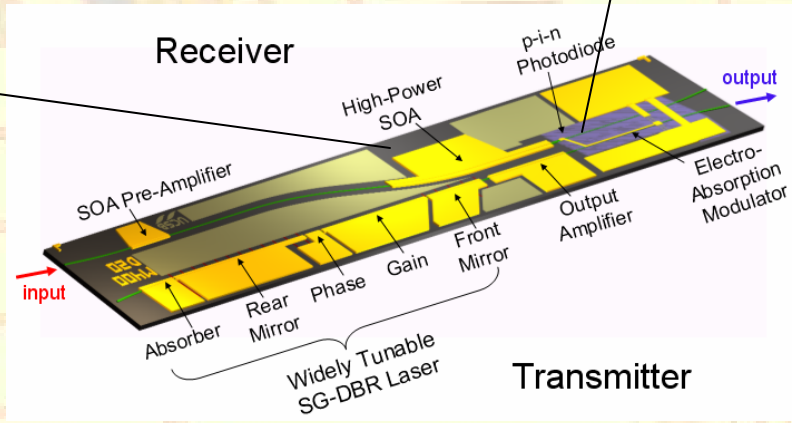


Optical Receiver Characterization

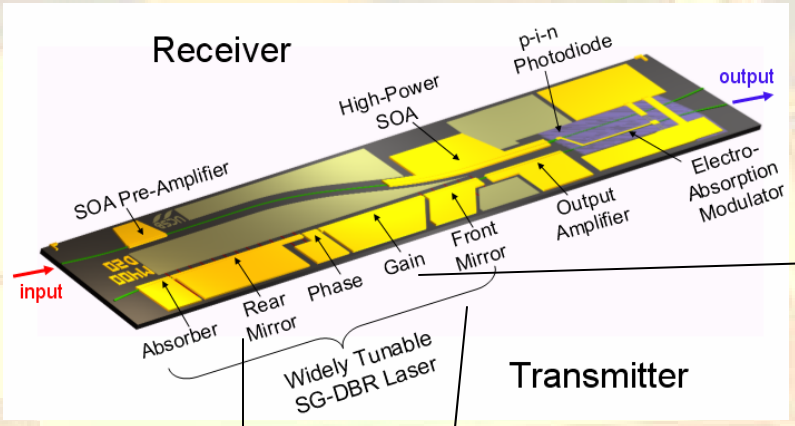
- The optical amplifier uses injected current to amplify light. We can measure the gain of amplifiers by sweeping drive current and measuring the output power into a photodiode. (below)
- We can also determine the maximum power handling capability of the SOA by measuring photodiode currents for increasing optical powers. (Right)

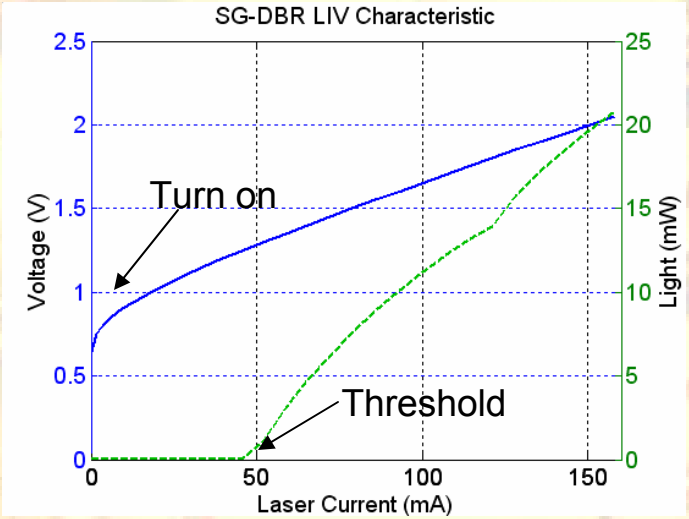


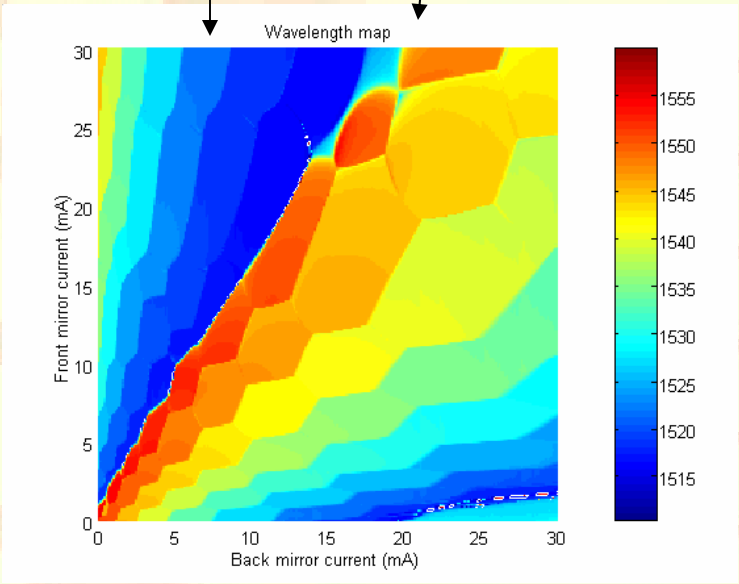




Laser Characterization

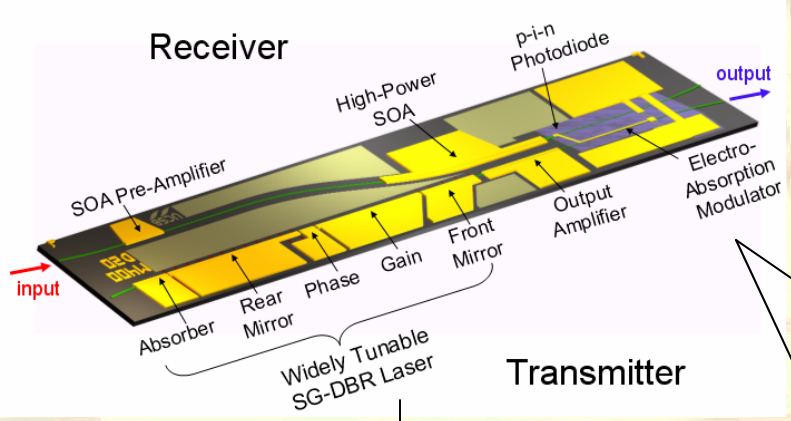




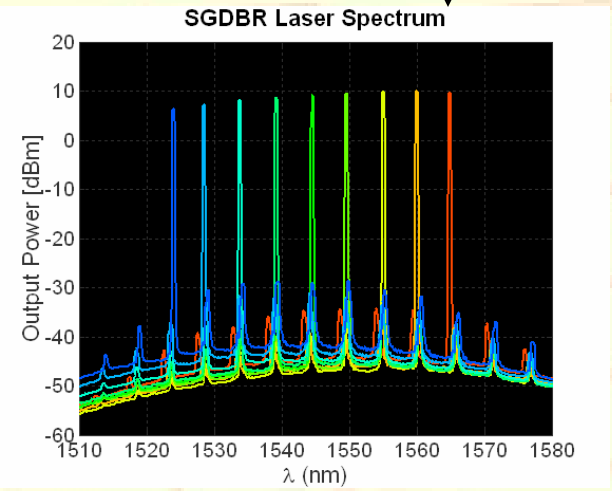


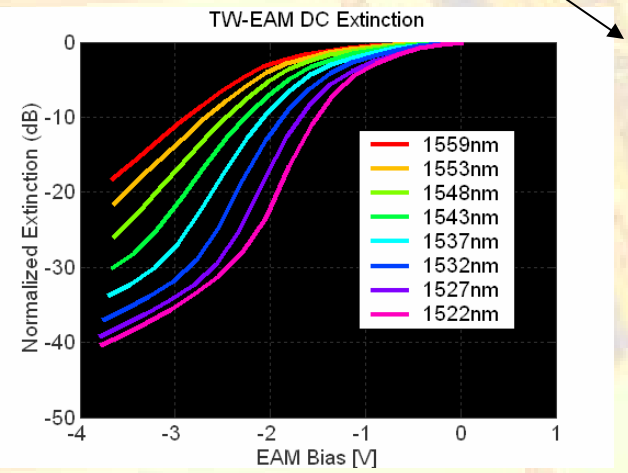
- We can sweep the drive current to the gain section of the laser to determine the voltage at which the diode turns on as well as the threshold current (i.e. how much current it takes to start producing light)
- The lasing wavelength can be tuned by applying a current to the front or back mirror sections. By sweeping both sections simultaneously, we can determine the full range of achievable wavelengths for the laser.

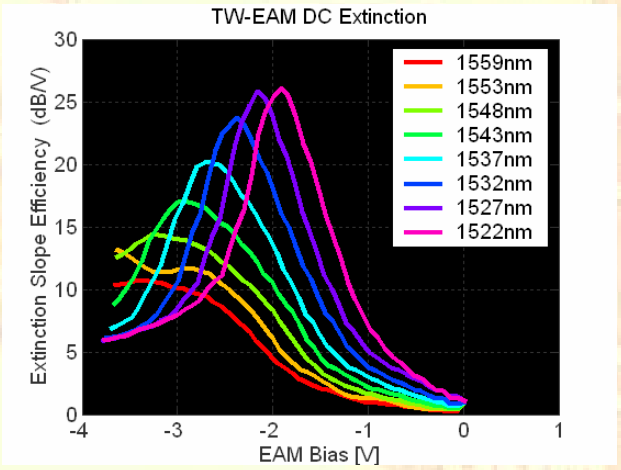
EAM Measurements



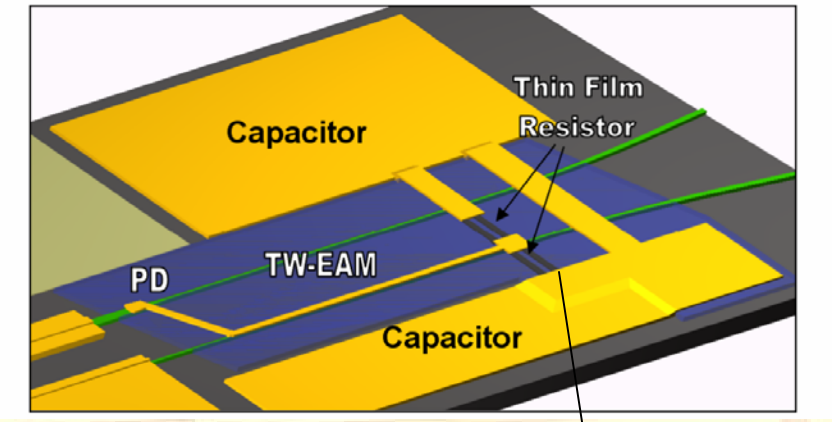
- An electro-absorption modulator is a diode which changes how much light it absorbs based on how much negative voltage is applied to it. It can be used like a shutter in front of a laser to convert electrical signals into optical signals.
- We characterize modulator efficiency by sweeping the voltage to determine how quickly it changes from transparent to highly absorbing at each wavelength. Shorter wavelengths (higher energy light) are more easily absorbed and typically require less voltage to go from "off" to "on".

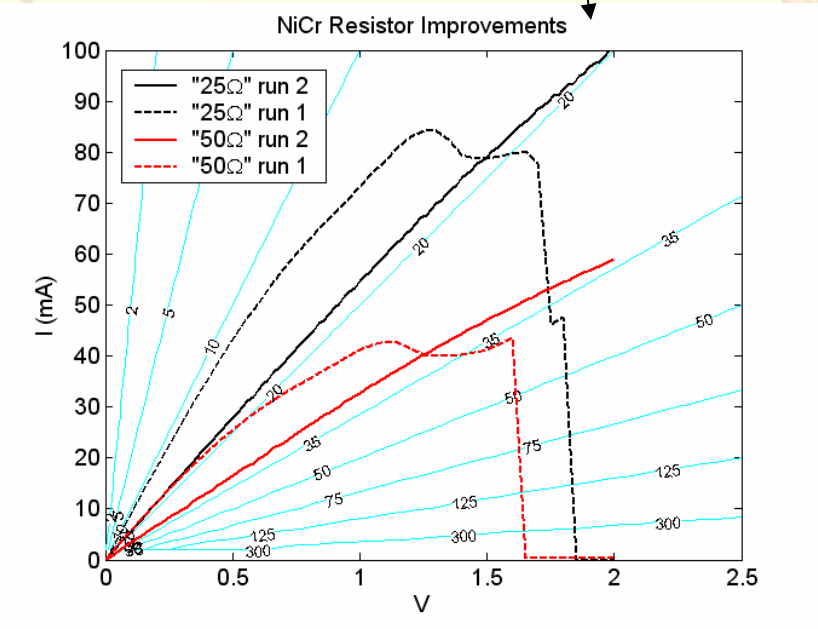






Others





– We can sweep voltage for integrated resistors to measure their resistivity, ohmic behavior (linearity), and failure point