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Silicon Photonic Resonant Heater-Modulator

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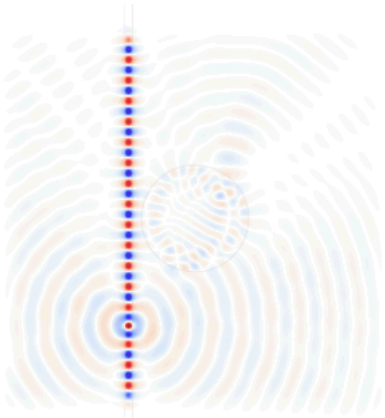
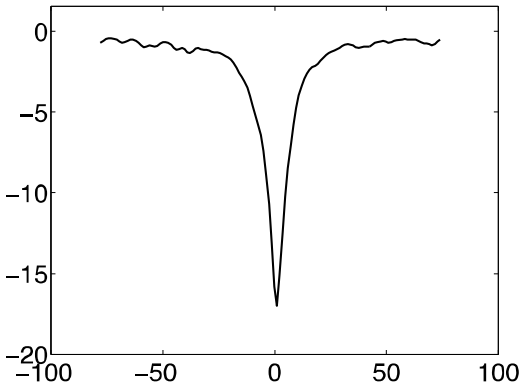
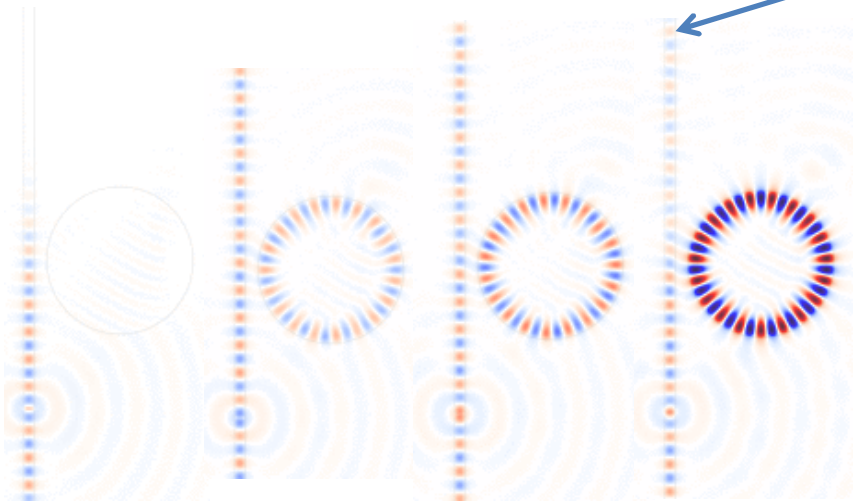
Resonant modulator basics

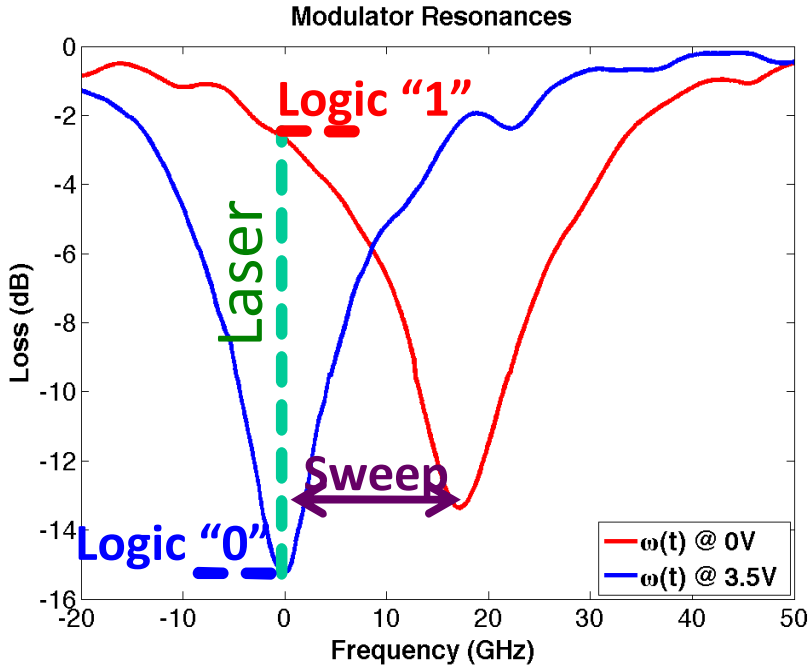
Off resonance there is only a DC carrier wave:





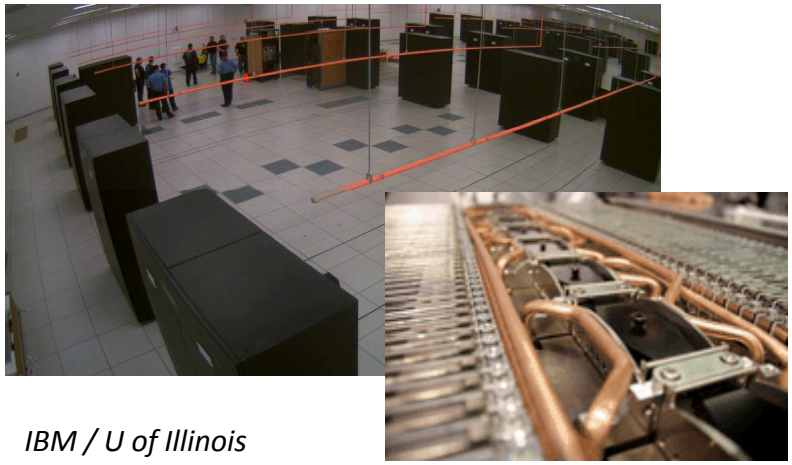
On resonance, a microwave signal can be imprinted on a CW laser carrier wave



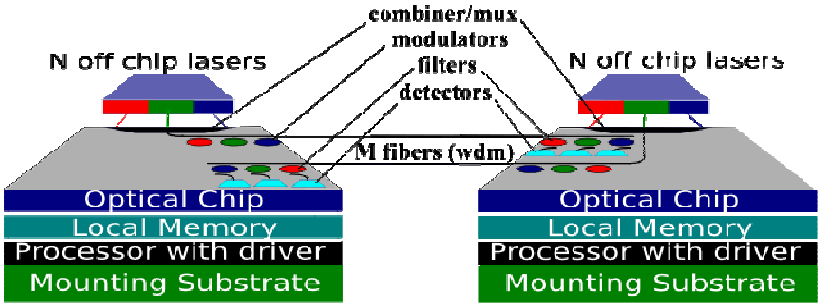


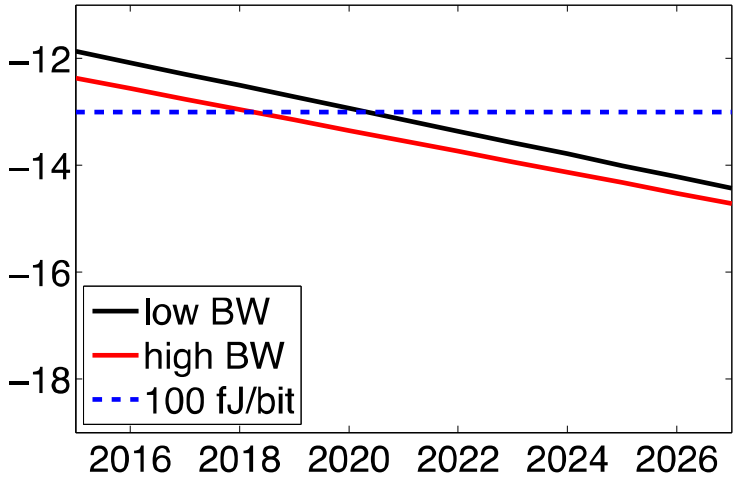
The primary intended purpose of such a sensitive modulator is supercomputer interconnect

Supercomputer



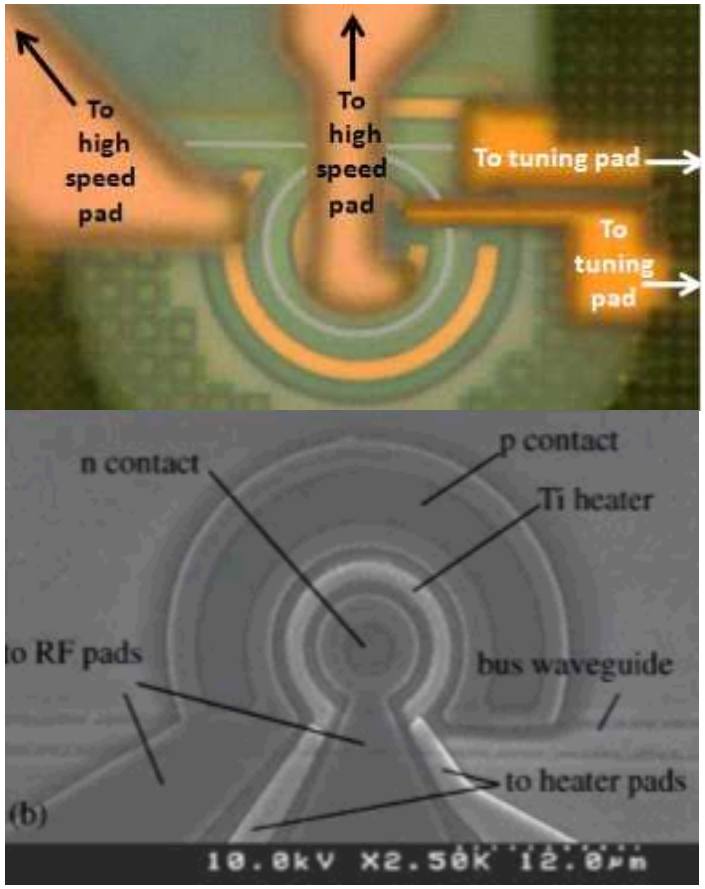
IBM / U of Illinois
Blue Waters, http://www.ncsa.illinois.edu/BlueWaters

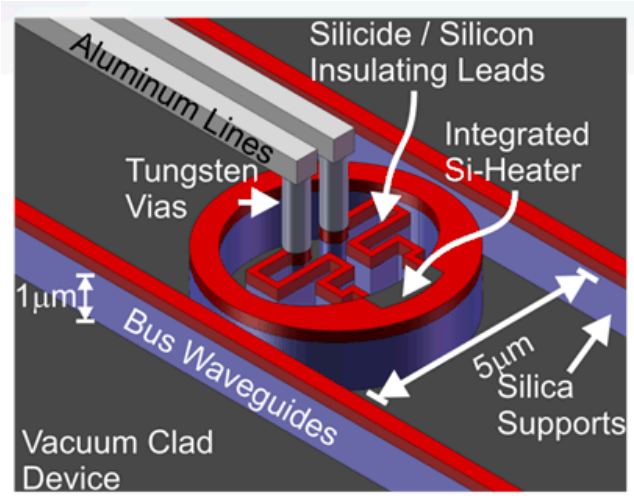




In addition, WDM architectures are simpler for large BW capacity.
Even so, each channel needs a TX and RX and so the BW density required is ~20Pb/cm/s

Demonstrations of integrated heaters

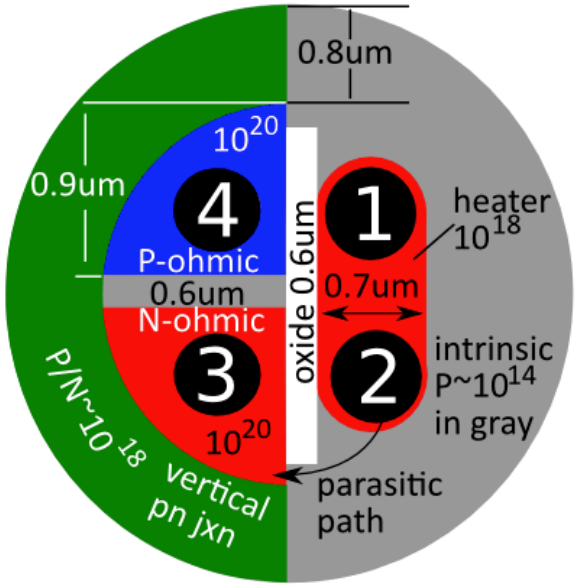


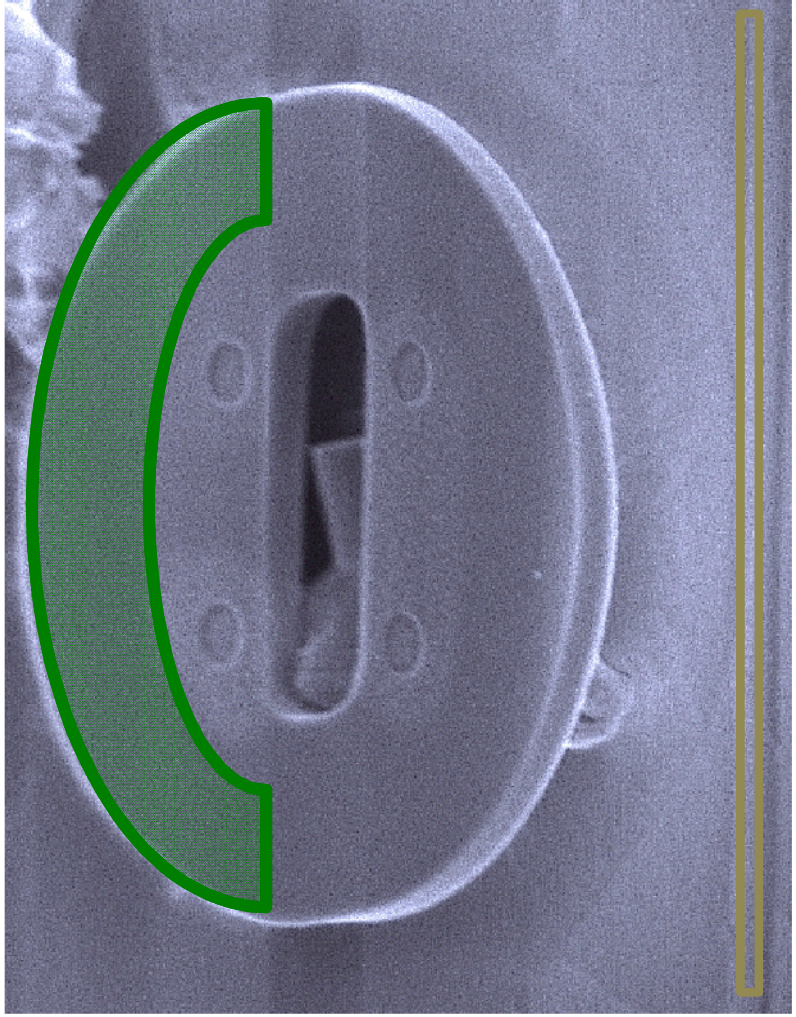


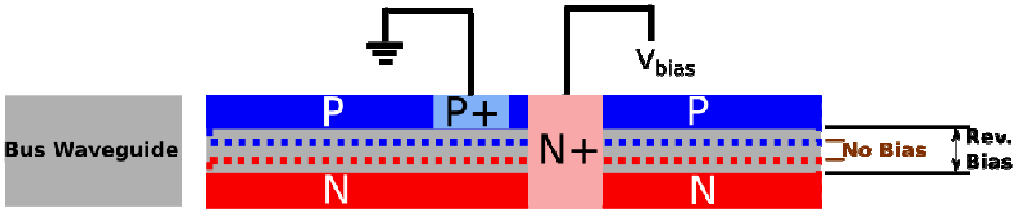
Chinese groups

European groups

Modulator design:







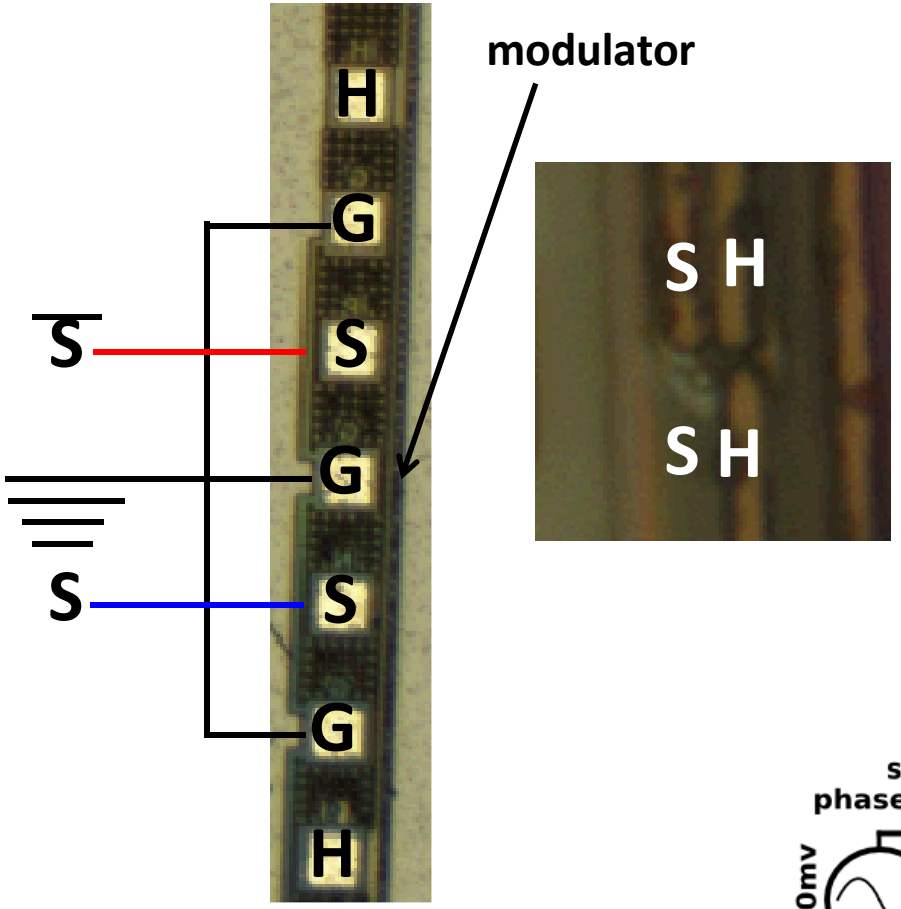
4.2 micron diameter

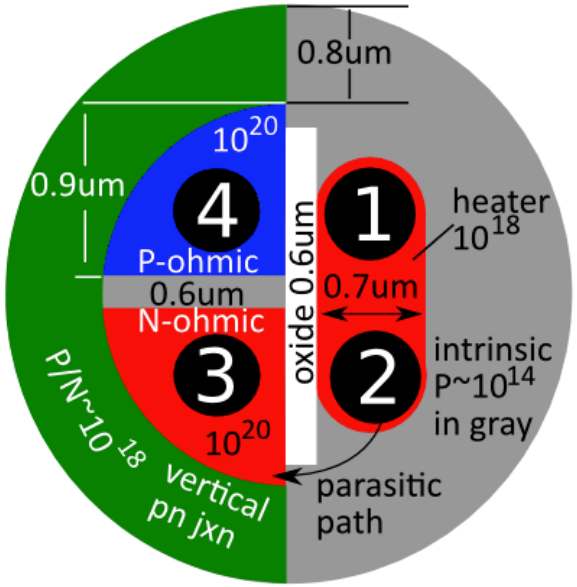
Silicon on Insulator 250nm thick silicon on 3µm buried oxide

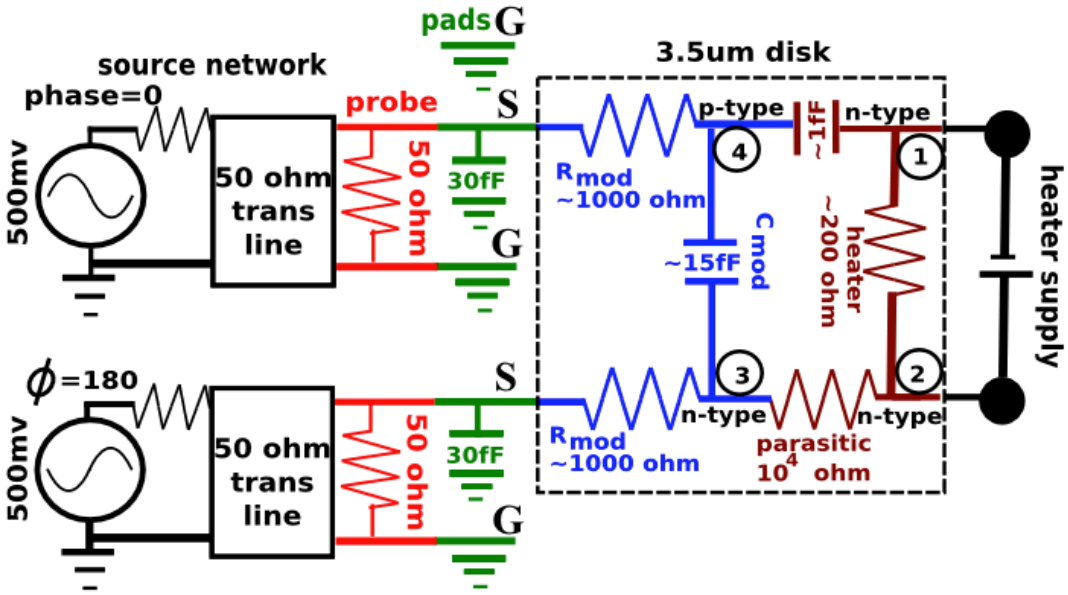
5µm deposited oxide over the device and waveguide

operates in reverse bias

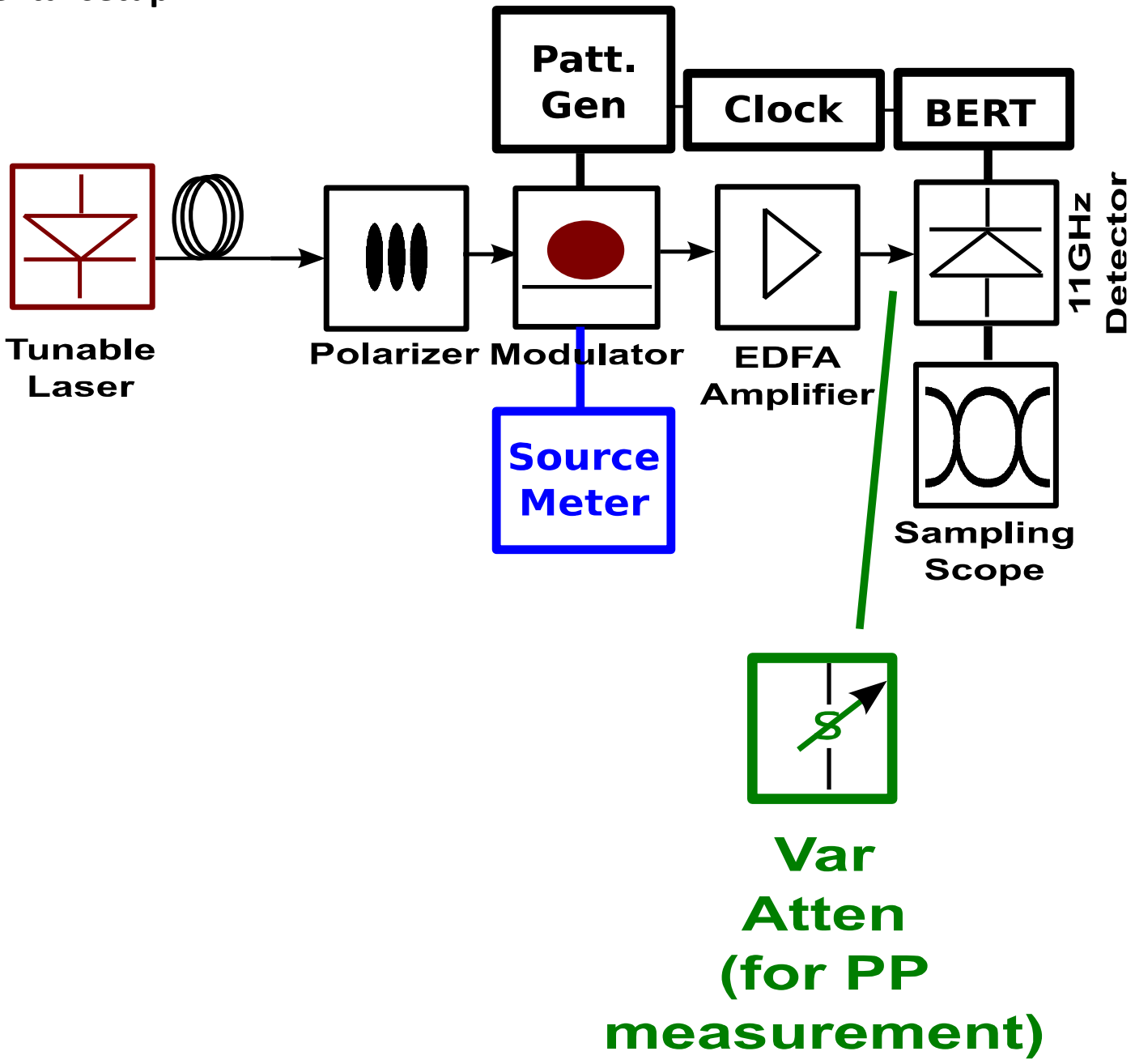
Circuit and Layout



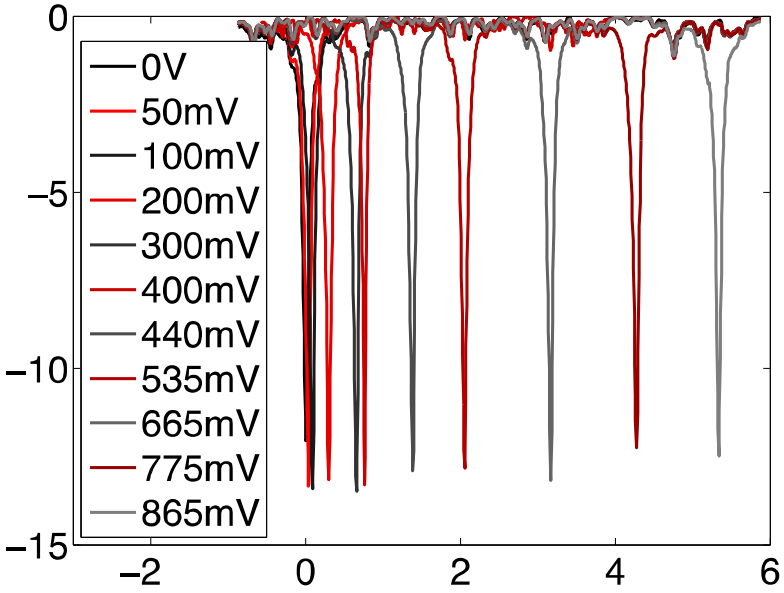


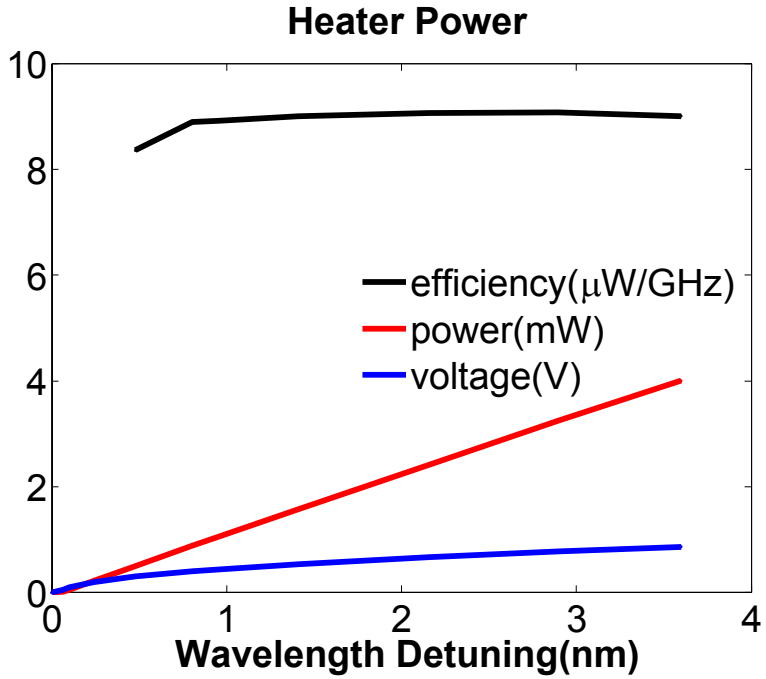


Experimental setup

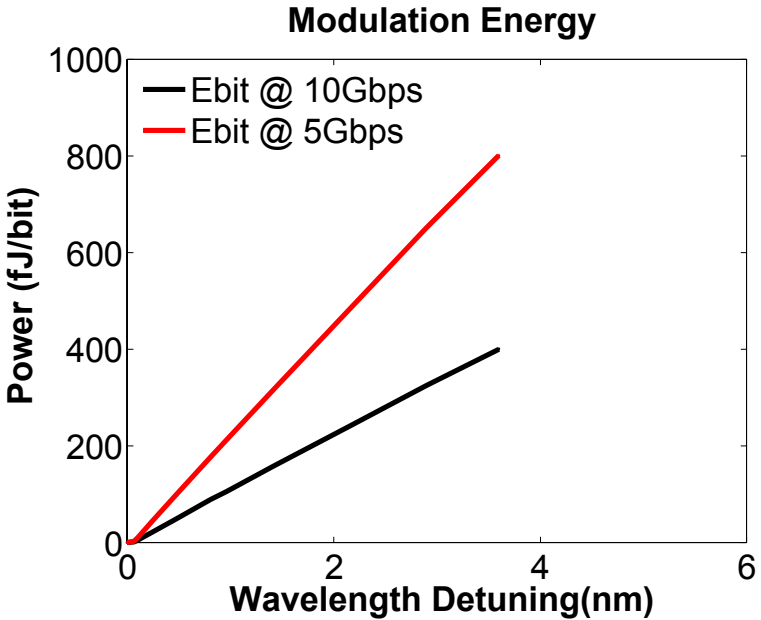


DC performance:





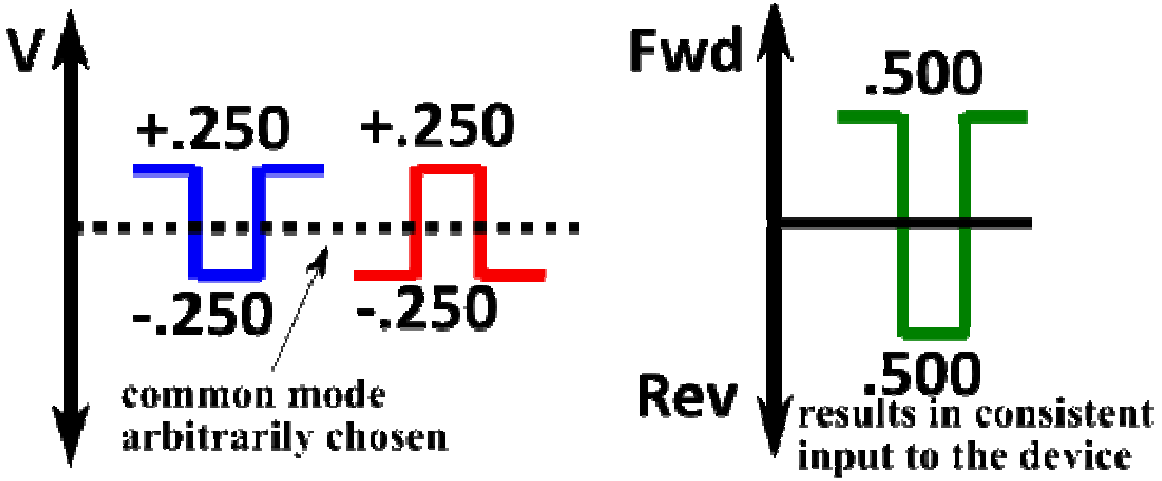
AC energy/bit performance:



This is a modulator figure of merit.

Does not include the laser, tuning/other circuitry and applies only to the Tx.

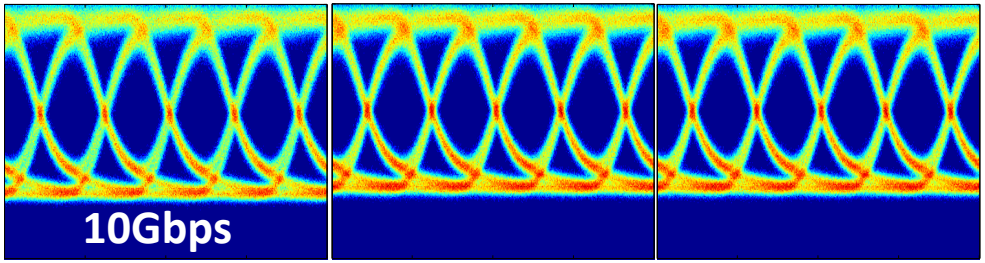
It is most desirable to differentially signal these parts for noise immunity and compatibility with low supply voltages.



common modes (AC or DC coupling)

0V **1.25V** **1.5V**

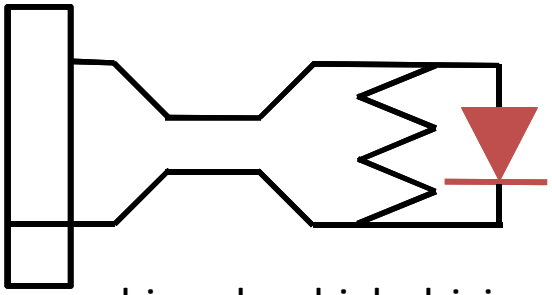
500mV



7dB ext.

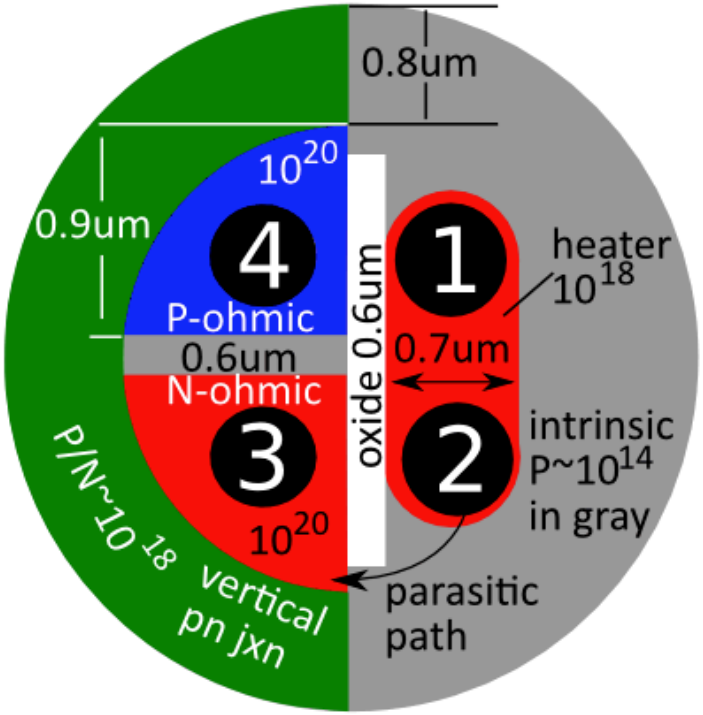
3.2fJ/bit

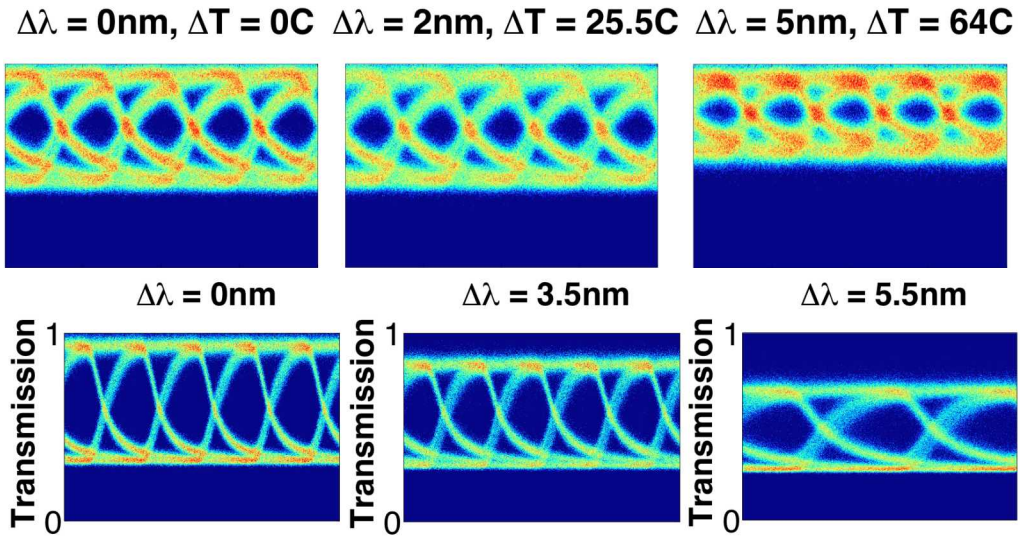
Compatible with LVCMOS, VCL, CML, LVDS and requires no special drivers

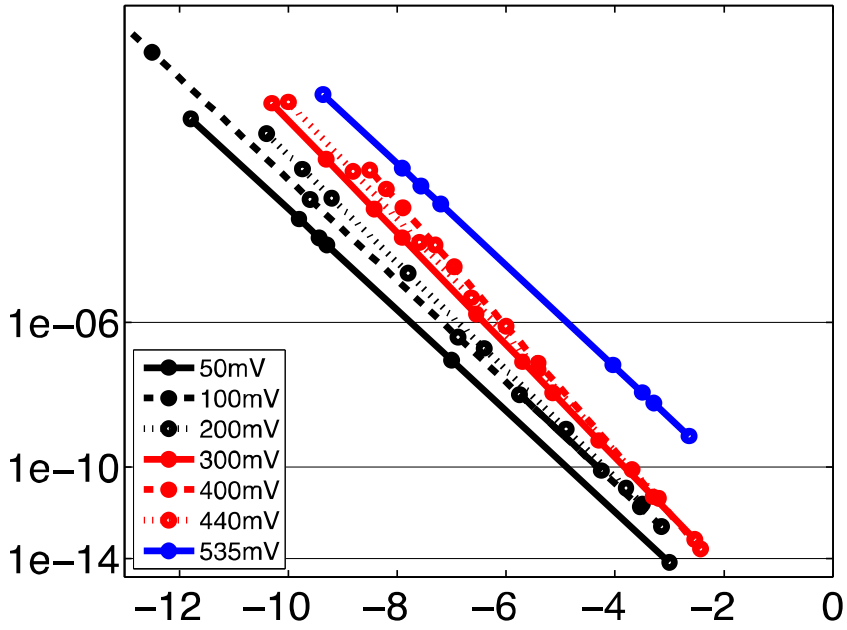


Yet the modulator is reverse biased so high driving currents are not required

Differential drive performance

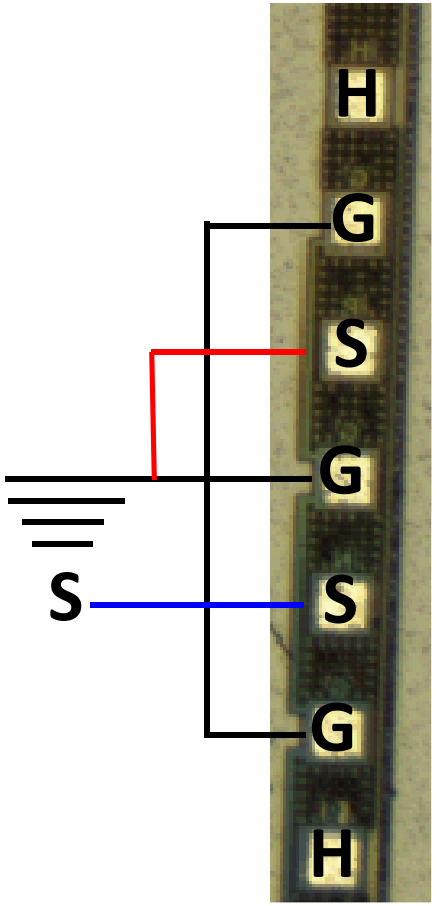


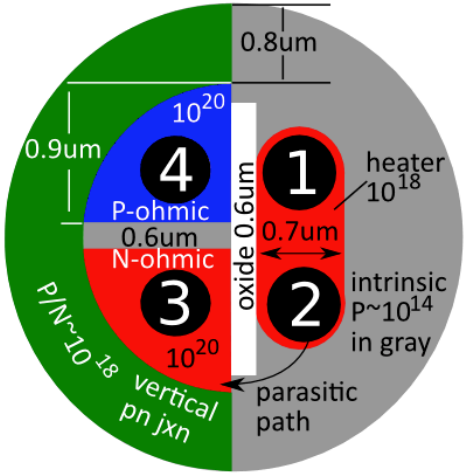


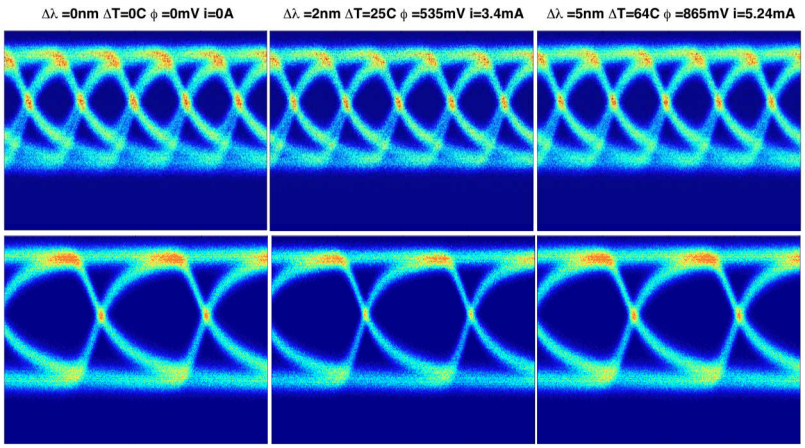


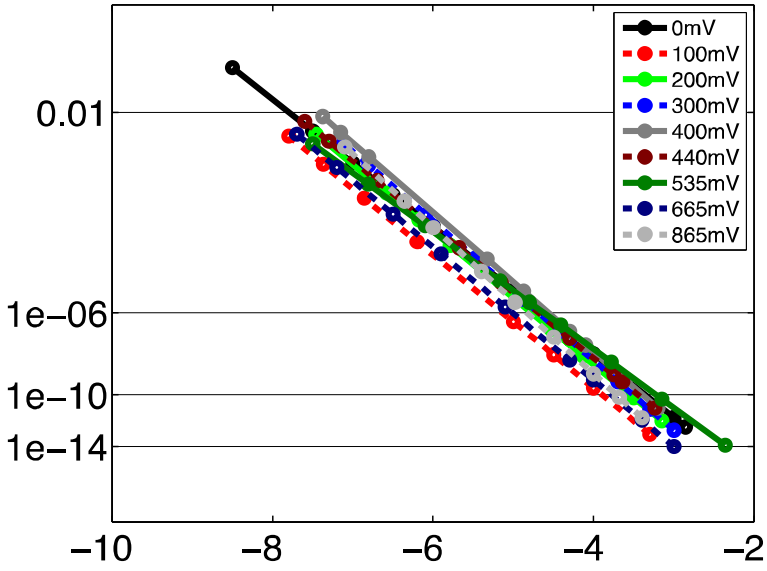
Better electrical isolation is needed to provide stable differential signaling.

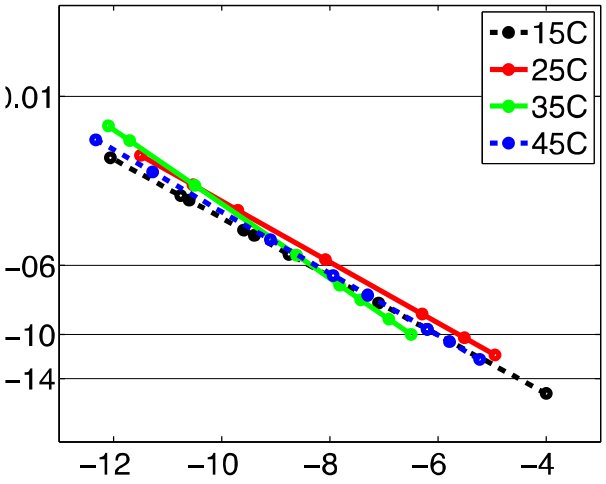
Reverse bias performance:











By grounding #3 and #2 the parasitic path disappears and low power penalties are observed.
Thermal flexibility of the modulator is confirmed using a TEC

Conclusion

Small Footprint Heater Modulator – 10um2 for 100Pb/cm2

LVDS compatibility with straightforward heater redesign

Works with $V_{dd}/2$

Low intrinsic efficiency

No signal degradation with heating

Tony Lentine will talk about a novel control circuit which uses this device at IEEE Optical Interconnect Conference in ***Santa Fe 20-23 May 2012***

Questions

William A. Zortman, Anthony L. Lentine, Douglas C. Trotter and Michael R. Watts

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