Argonne NATIONAL LABORATORY

Radiation-Hard Optical links for detector readout

A. Paramonov for ANL group

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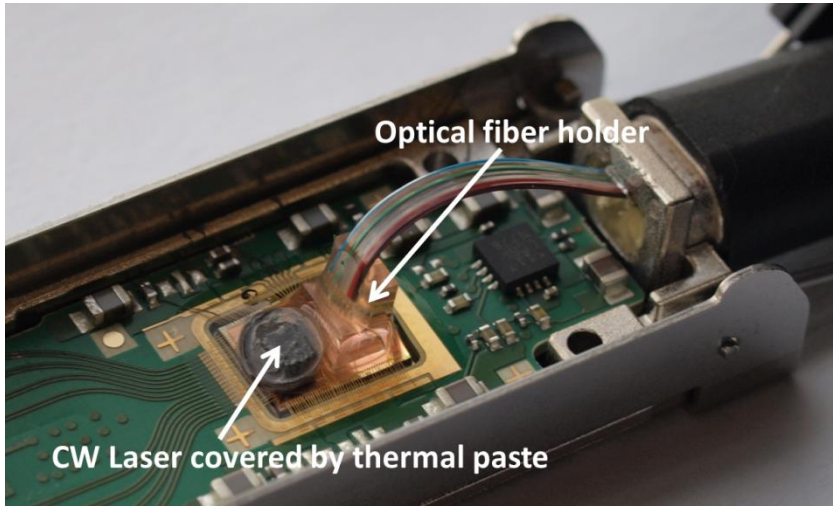
Lol overview

- Argonne has characterized radiation tolerance of commercial Si-photonics optical transceivers for the ATLAS experiment at the LHC. Other institutions (e.g. CERN) have also looked at the technology.
  - The optical components were found to be highly radiation tolerant.
- Target: TID~ 3 Mrad, NIEL~ 1e17 n/cm^2, 10-50 Gbps/fiber.



- The Si-photonics approach allows fabrication high-speed, low-cost, low-power, high-reliability, and low-BER fiber-optical transceivers
- Si-photonics utilizes fabrication of optical circuits in the same wafer as electrical circuits using conventional CMOS processes. →"Fiber to chip" instead of copper cable
- E.G. The technology could significantly reduce the mass, complexity, and power consumption of the ATLAS inner tracker while also improving its performance.
- <u>The HEP community could benefit from further adopting the technology</u> through partnership with commercial companies or by developing our own devices and expertise. The Si-phonics device libraries are widely available.

BACKUP

Si photonics technology uses a commercial CMOS SOI process (see 10.1109/JSSC.2007.908713 or 10.1109/OFC.2008.4528356). The optical elements are:

- Passive waveguides (losses<0.1 dB/cm) → interconnects between other optical devices.
  - Utilize the high index of refraction between Si and SiO_2.
- Phase modulators → Used in the MZI-based amplitude modulators
  - The refractive index of Si depends on the free carrier density (electrons and holes)
  - Implemented as a PN diode structure by using implants
  - Bias the PN diode to change the phase
- High-speed photo detectors
  - Selective growth of Ge on top of the Si waveguide.
- Low-loss grating couplers, holographic lens (efficiency ~ 95%)
  - Used to couple light in and out of the Si die
  - Redirect light from horizontal direction (die) to vertical (fiber)

From D. Kucharski, Hot Chips 21, Aug. 24, 2009