Status of Opto-Boards

K.K. Gan
The Ohio State University

September 28, 2004

K. Arms, K.K. Gan, M.O. Johnson, H.P. Kagan, R.D. Kass,
A. Rahimi, C Rush, R. Ter-Antonian, M. Zoeller
The Ohio State University

A. Ciliox, M. Holder, M. Ziolkowski
Siegen University

Outline

- Improvements in Assembly Procedure
- Changes in Opto-board Layout
- Results from Irradiated Opto-boards
- Summary

Problems in Opto-Board Assembly

- soldering of opto-pack leads to opto-board:
  - use jig to transfer heat to all leads simultaneously
  - occasional cold solder joints and detachment of leads inside opto-pack
  - adjustment of high-temperature Teflon jig for each opto-board
- wire bonding:
  - low pull strength due to inadequately cleaned surfaces and not optimized bonding parameters
  - ⇨ occasional opto-board failure after burn-in/thermal cycle
  - ⇨ one channel in spare opto-board failed intermittently during annealing after ~30 Mrad

Improvements in Opto-pack Soldering

- solder one lead at a time with modified soldering tip:
  - file tip off at an angle
  - engrave a groove of rectangular cross section to increase contact area for heat transfer
  - trim the blunter tip to avoid contact with adjacent leads
  - achieve repeatability using soldering jig with a bar as arm rest for soldering iron
    - ⇨ same soldering angle for consistent heat transfer
  - clean flux off with flux solvent (isopropyl) for ease of inspection of solder quality
  - ⇨ consistent good soldering with contact time < 15 s
  - ⇨ no detachment in 17 opto-packs (170 leads)

Improvements in Wire Bonding

- single opto-pack lead soldering requires no rework
  - ⇨ cleaner wire bond area!
- re-optimize wire bonding parameters
- successfully fabricated two opto-boards with double bonds
  - good pull strength with a minimum of 7.5 gmf

Improvements in Chip Masking

- chips are masked to prevent contamination from flux
- weak UV light source causes oxygen inhabitation in mask curing
  - ⇨ mask not fully cured
  - ⇨ mask residues remain after mask was peeled
  - ⇨ lower wire bond quality
  - ⇨ strong UV light source on order

Connector Alignment Jig

- alignment holes for the 80-pin connector on new opto-boards could be under or over-sized
  - ⇨ connector jigs must be prepared as a fall-back solution
    - 2 out of 3 jigs passed assembly test on 5 opto-boards at assembly vendor
    - 5 more jigs were fabricated
      - ⇨ 2 passed measurement at OSU
      - ⇨ now at assembly vendor await testing on new opto-boards

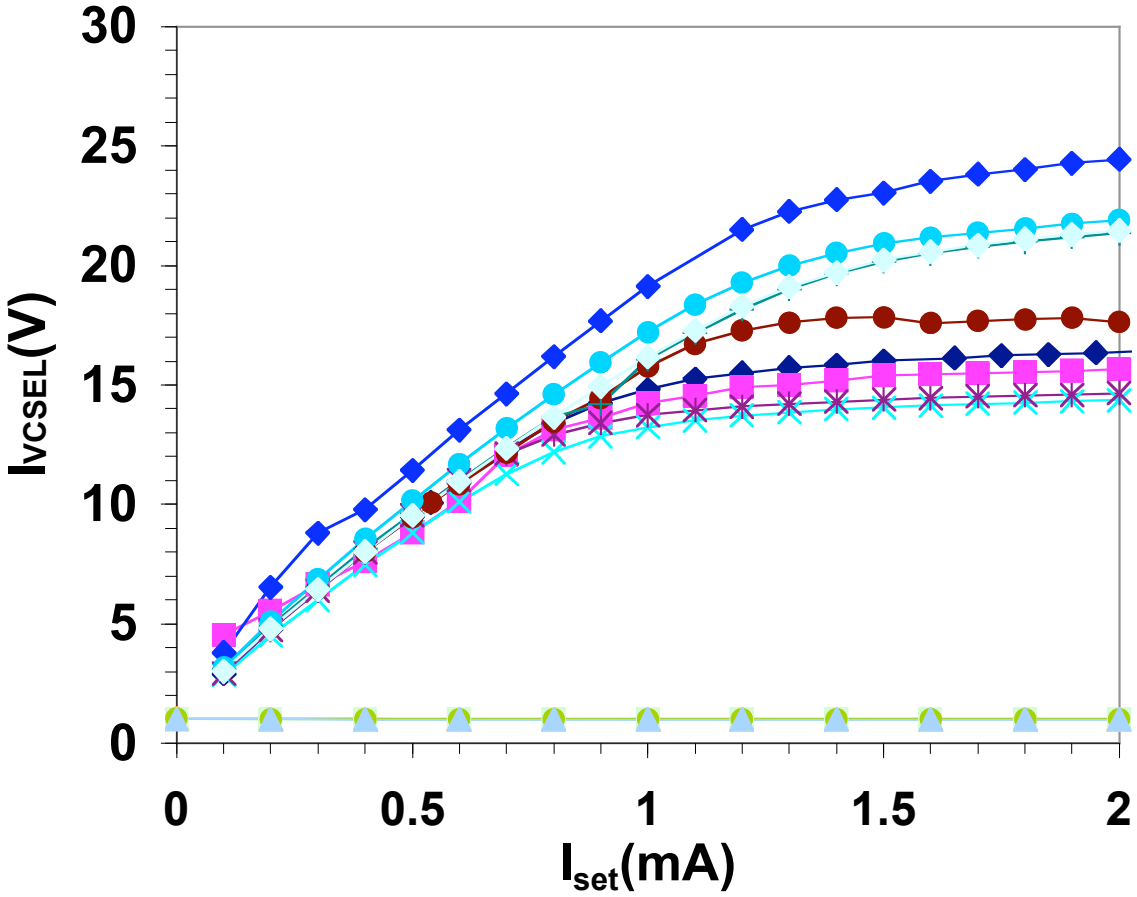
Status of Opto-Board Production

- 4 boards produced and passed QA with new assembly procedure
  - ⇨ no rework required!
- 1 opto-board has been burned in and currently in thermal cycle
- 2 opto-boards have opto-packs soldered and ready for wire bonding
  - ⇨ yield = 100% based on 4 boards
  - previous yield = 50% based on 10 boards produced with trials of various assembly procedures

Status of New Opto-Board Production

- several SMDs fell off in 3 out of 28 prototype opto-boards
  - ⇨ remove wire-bondable gold underneath solderable gold
  - ⇨ expect to improve adhesion and solderability
- ordered all blank boards needed to shorten fabrication time
  - status: delivered
- 80 b-layer boards with design changes were ordered
  - status: shipped yesterday (Monday)
  - ⇨ assemble 10 boards for evaluation
    - could be ready to submit Layer 1/2/disk design in 3 weeks

Maximum VCSEL Current

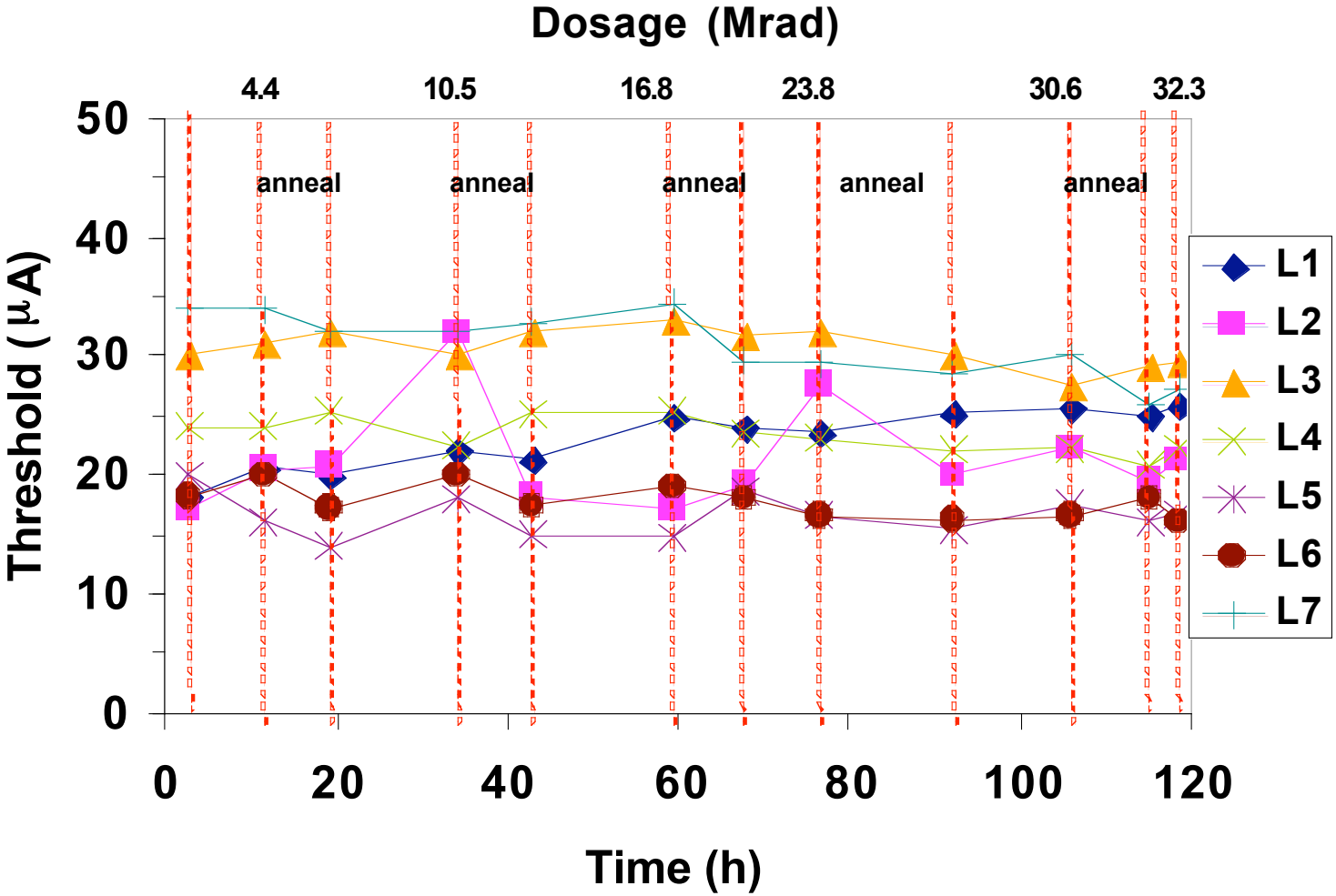


- some new VCSELs require lower voltage to produce a given current
  ⇨ > 20 mA in VCSEL when driven by VDC

Results on Proton Irradiation

- 4 opto-boards were irradiated with 24 GeV protons at CERN
  - dosage: ~30 Mrad
  - expected lifetime dosage: ~20 Mrad

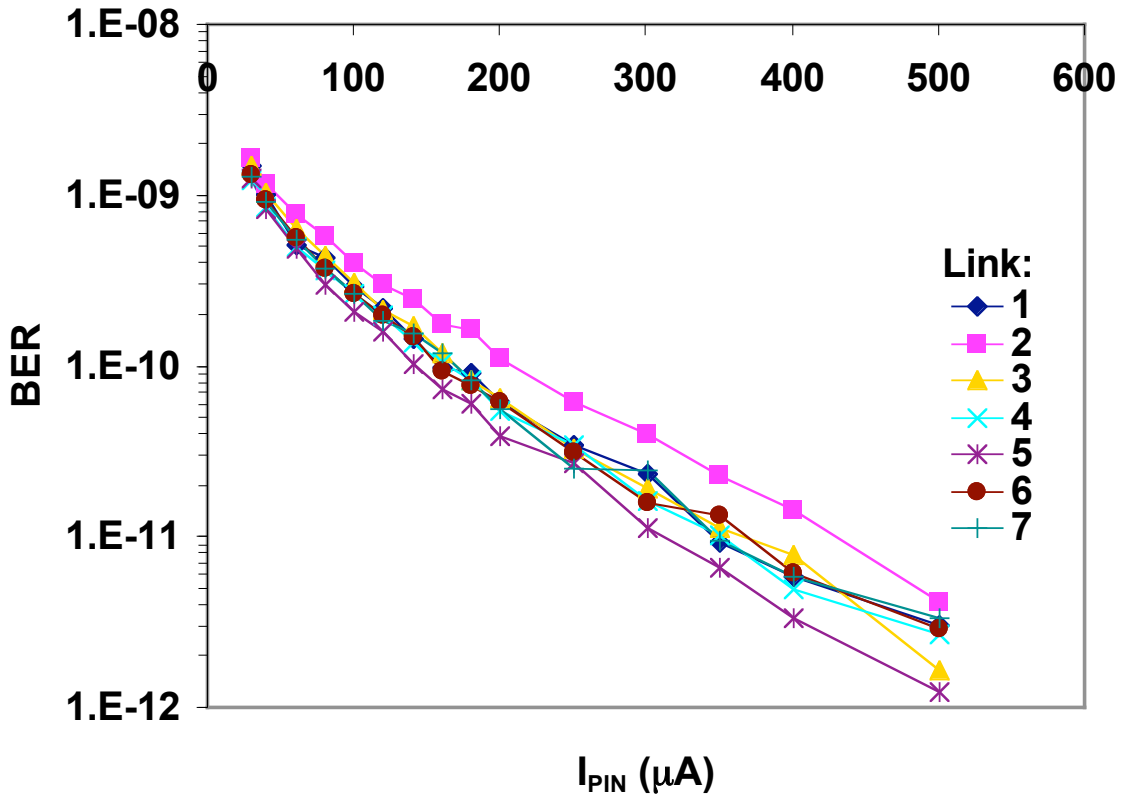
PIN Current Threshold vs Dosage



- PIN current thresholds for no bit errors remain constant

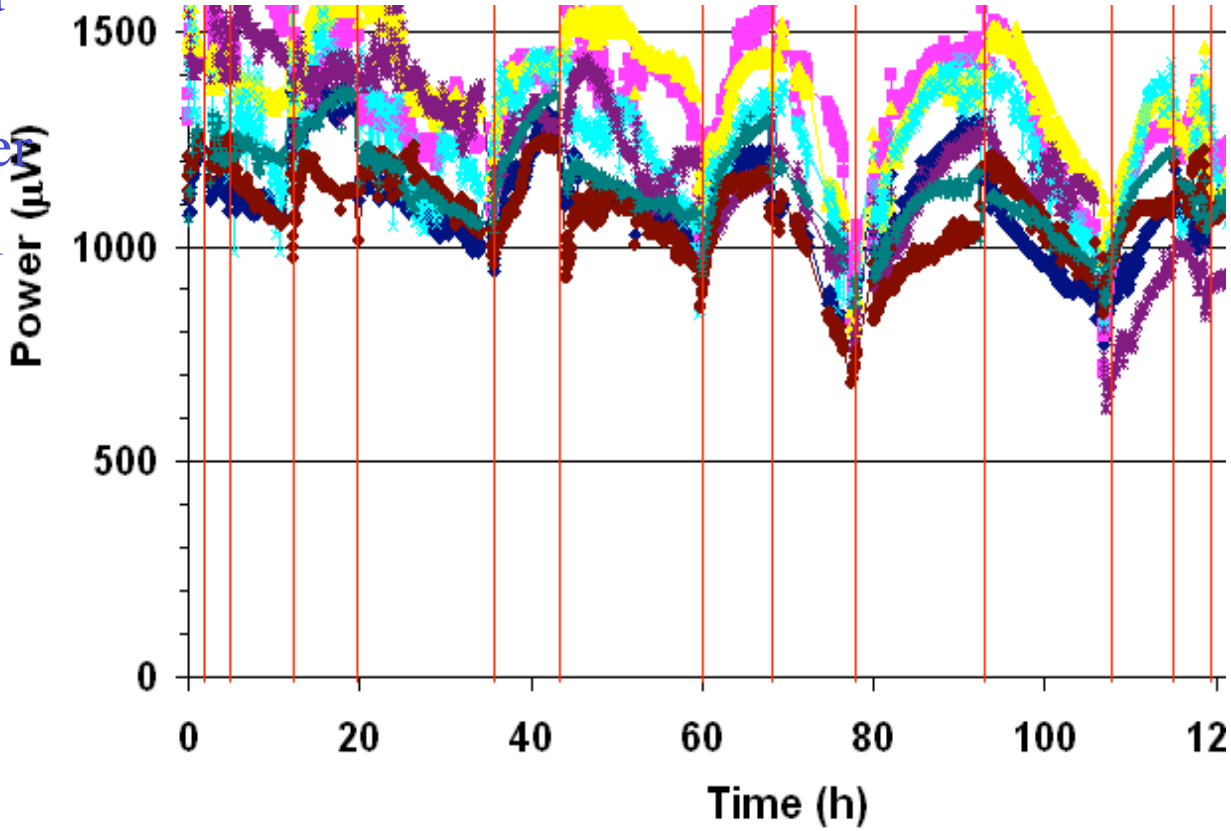
Proton Induced Bit Errors in PIN

- convert observed bit errors into bit error rate at opto-link location
- bit error rate decreases with increasing PIN current as expected
- bit error rate ~ 3 x 10^{-10} at 100 μA (1.4 errors/minute)
  - DORIC spec: 10^{-11}
  - ⇨ bit error dominated by particle induced PIN current



Optical Power vs Dosage

- irradiation procedure: ~ 5 Mrad/day (10 hours) with the rest of day annealing
- optical power decreases with dosage as expected
- limited annealing recovers some lost power
- still have good optical power after 30 Mrad



Summary

- improved opto-board assembly procedure
  ⇨ much more reliable production
- CPT has produced 80 b-layer opto-boards
- VCSEL opto-packs on opto-boards produce good power after 30 Mrad