New Results on Opto-Electronics

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Outline

- Irradiated VDC/DORIC-I5e Results
- Results from New Opto-board
- Results from Irradiated Opto-boards
- Summary
VDC-I5e: Rise/Fall Time + Duty Cycle

- rise time < 1 ns
- measured with 44-pin package
- faster rise time on opto-board
- fall time < 1 ns
- duty cycle < (50 ± 4)%
DORIC-I5e: Clock Rise/Fall Time + Duty Cycle

![Graph showing CLK Rise/Fall Time and Duty Cycle](image)

- **CLK Rise Time (ns)**
  - Channel 1: 0.6
  - Channel 2: 0.6
  - Channel 3: 0.6
  - Channel 4: 0.6

- **CLK Fall Time (ns)**
  - Channel 1: 0.4
  - Channel 2: 0.4
  - Channel 3: 0.4
  - Channel 4: 0.4

- **CLK Duty Cycle (%)**
  - Pre-irrad: Min: 45%
  - Spec: (50 ± 4)%
  - Close to 50% on opto-board

- **Legend**
  - Rise time < 1 ns
  - Fall time < 1 ns
  - Duty cycle:
    - Min: 45%
    - Spec: (50 ± 4)%
    - Close to 50% on opto-board
DORIC-I5e: Clock LVDS Output

- no change in clock LVDS amplitude
- acceptable shift in clock LVDS level
Summary of VDC/DORIC-I5e

- acceptable degradation in VDC and DORIC after 55 Mrad
Construction of New Opto-Board

- traces of opto-packs connected to opto-board via wire bonds
- limit epoxy curing temperature to 80°C
  - curing temperature of previous two opto-boards: 100°C
both VCSEL opto-packs have good power on opto-board
powers are comparable to those before mounting on opto-board
Corrosion on Opto-board Traces/MT Guide Pins?
Corrosion on Opto-board Traces/MT Guide Pins?

- brown whiskers on MT guide pins easily removable
  - surface looks shiny after removal
- no whiskers on wire bonds connecting to chip pads
- white whiskers on wire bonds connecting to gold traces
  - broken continuity between wire bonds and traces
  - no whiskers on wire bonds protected with optical epoxy
- can grow whiskers for opto-board in moist environment within days
  - whiskers likely from condensation during cooling test at CERN
- no whiskers on opto-board after 6 days at $70^\circ$C
- no whiskers on opto-boards produced 6 months ago in lab environment
  - protect wire bonds with optical epoxy?
  - need to repeat tests with opto-boards from new vendor
Opto-board: LVDS Rise/Fall Time + Duty Cycle

- Rise time < 1 ns
- Fall time < 1 ns
- Duty cycle: (50 ± 4)%

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ATLAS Pixel Opto-Power Meeting
Opto-board: Optical Rise/Fall Time + Duty Cycle

- Rise time < 1 ns
- Fall time < 1 ns
- Duty cycle: (50 ± 4)%
Opto-power vs Annealing Time

BeO #3

- lowest annealed power close to 350 mW spec
Opto-power vs Annealing Time

- Lowest annealed power somewhat below 350 mW spec

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ATLAS Pixel Opto-Power Meeting
recover most of lost power after annealing/with no long cable
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bare fiber measurements indicate VCSELs still produce large power
20% reduction in power due to heating of opto-board
Analysis of Power Loss

- no power loss for a VCSEL opto-pack after 1 week at 100°C
- SIMM (rad-hard) to GRIN cable: 20% (1.0 dB)
- thermal loss: 20%
- specs:
  - minimum power: 500 mW
  - maximum radiation loss with annealing: 30%
- minimum power after irradiation/annealing: 224 mW
- observed lowest power: 214 mW
- acceptable power loss?
VCSEL Mortality

- two channels died before irradiation:
  - one channel is open and one behaves like diode (1.4 V)
- BeO #4: opto-packs salvaged from BeO #2
  - one channel died after irradiation: diode
  - two more channels have died
    - autopsy in progress…

⇒ infant mortality and/or radiation damage?
Summary

- acceptable degradation of VDC/DORIC-I5e after 55 Mrad
- lowest observed optical power after annealing consistent with expectation