ULM 10 Gb/s VCSEL Array Accelerated Lifetime Study

K.K. Gan, H.P. Kagan, R.D. Kass, J. Moore, S. Smith
The Ohio State University

June 8, 2012

Outline

- Test setup
- Result and failure analysis
- Summary

Overview

- Performed an accelerated lifetime test:
  - 20 VCSEL arrays from ULM (10 Gb/s)
  - mounted on OSU opto-packs
  - operated at 85°C and 85% relative humidity over extended time
  - all 240 channels continuously operated at 10 mA DC
  - aggregate VCSEL current/power from each array monitored with a wide area photo-diode
  - LIV (light-current-voltage) measurement every ~500 hours
- Test meant to qualify the use of ULM arrays mounted on the OSU opto-pack
  - believe that the arrays themselves are qualified

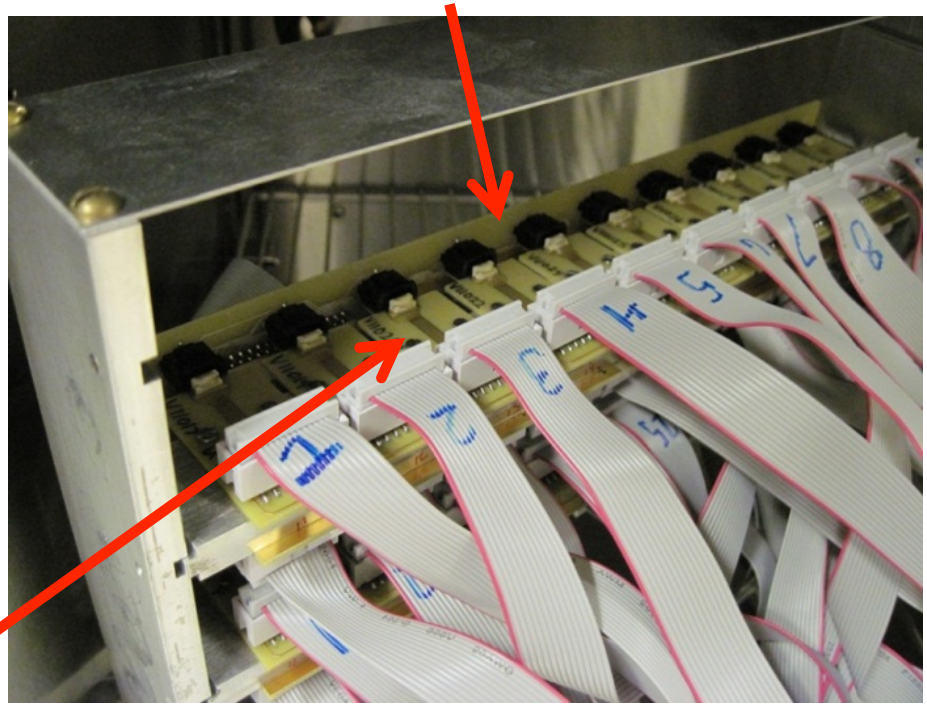
Light-Current-Voltage Measurements

Date	Operating Hours
27/9	0
13/10	380
08/11	1,002
29/11	1,510
28/12	2,200

Test Setup

Environmental chamber

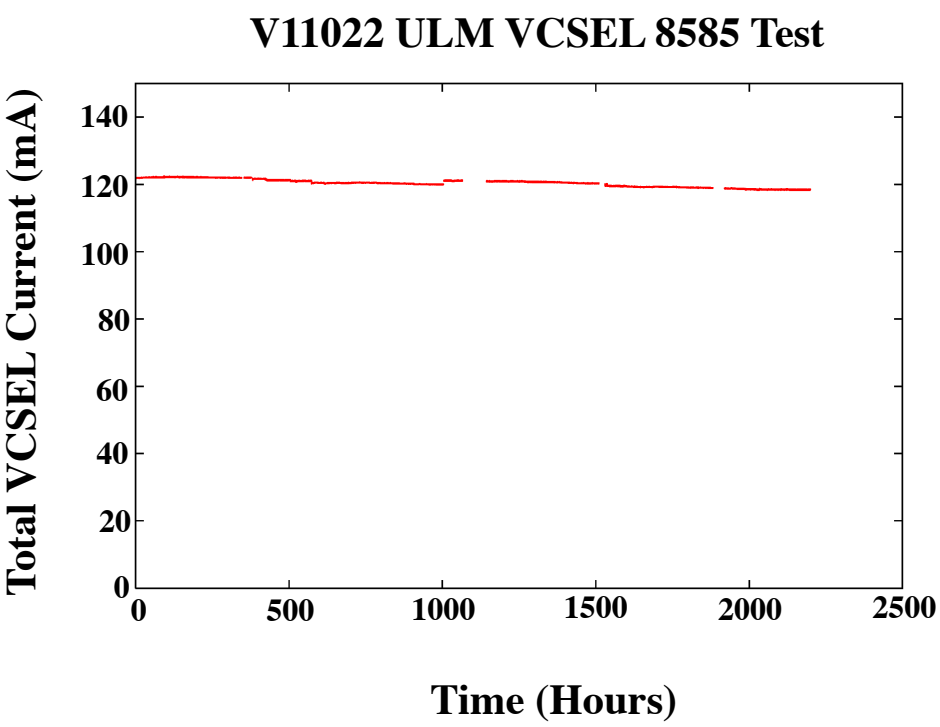
Wide area photo-diode mounting card

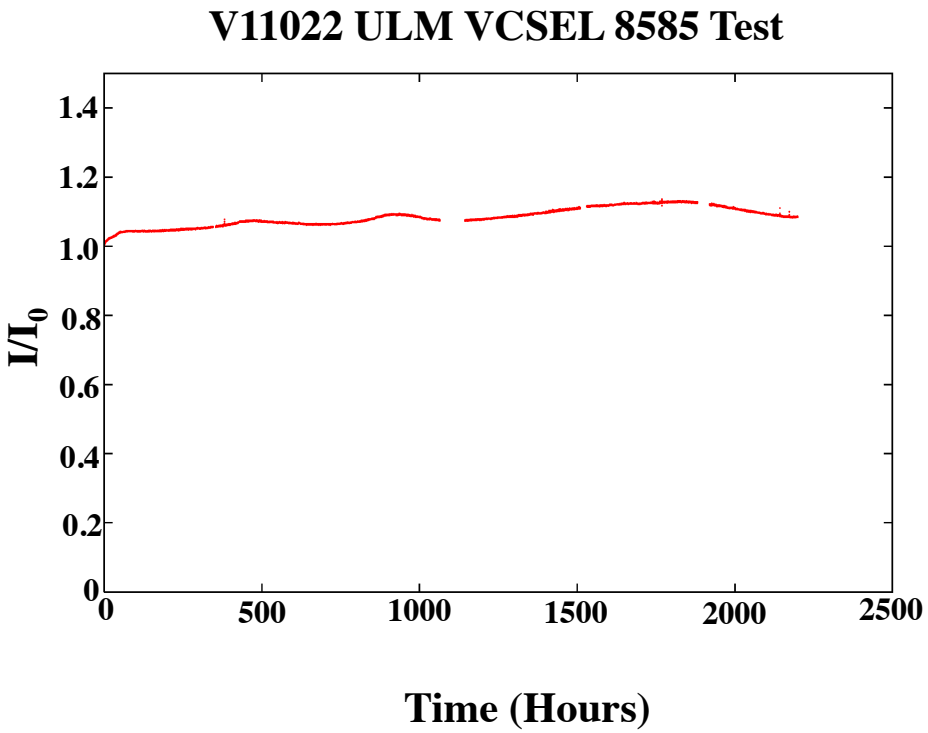


Single array test card

VCSEL Current/Power

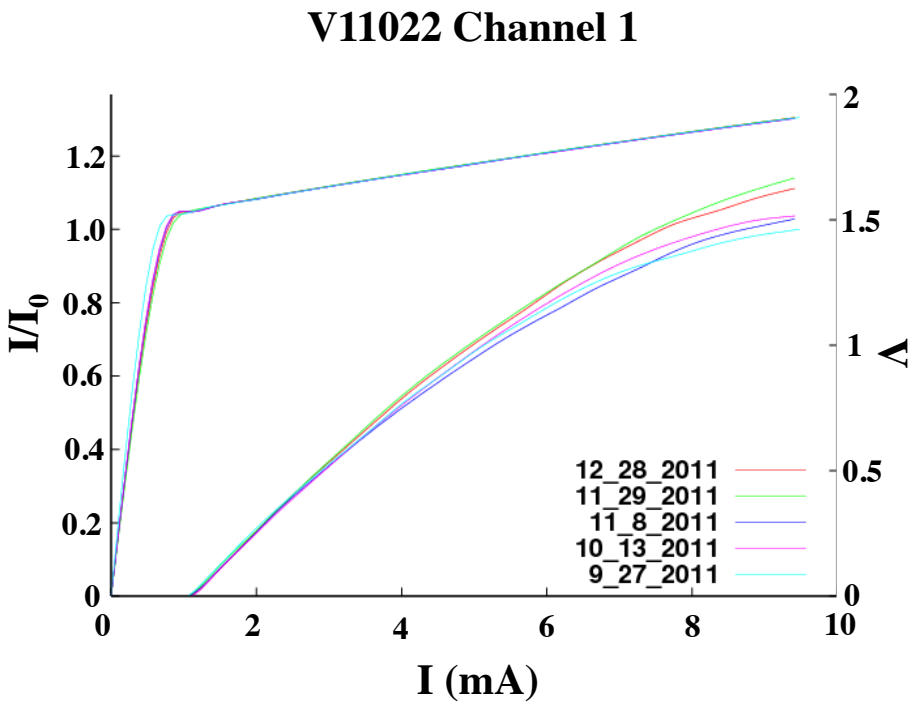
- Aggregate VCSEL current and light output for all arrays recorded continuously

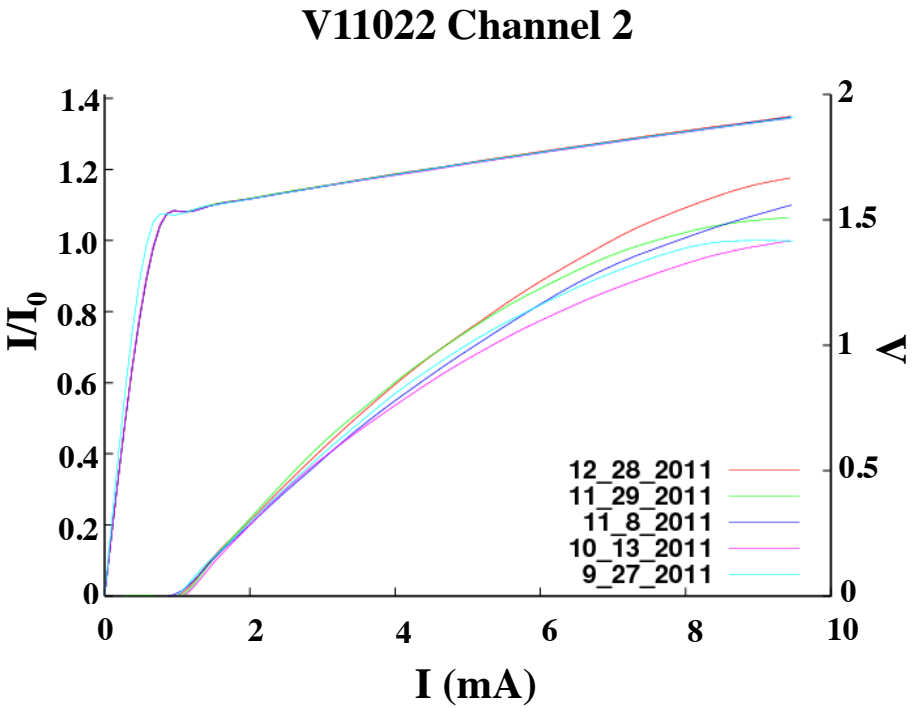




LIV Measurements

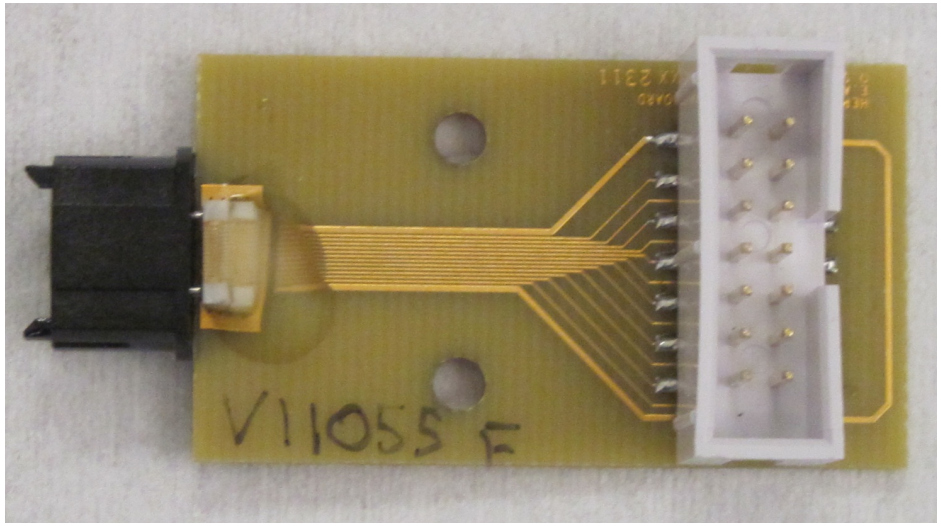
- Performed periodic LIV measurement on each channel
  - measured at 85°C



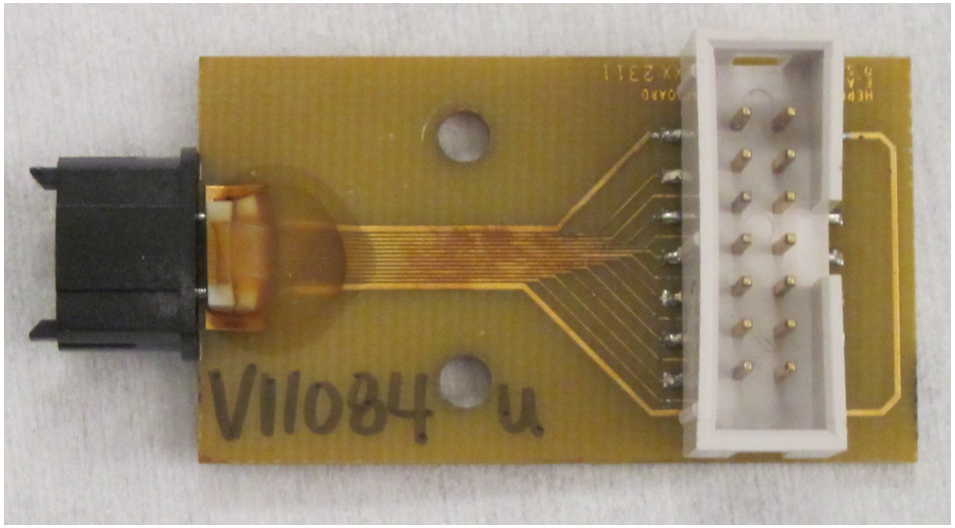


Visible Effects of 85/85 Test

Untested array/PCB
room temp/humidity



Array/PCB after 2200 hrs
85°C/85% Humidity



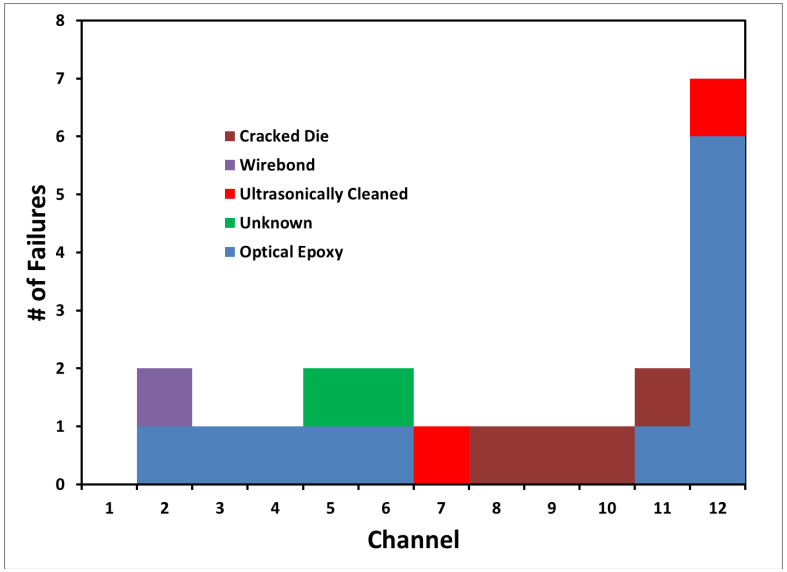
Results

Hours	Failed Channels
1,002	0
1,510	2
2,200	19

- Failure study:
  - visual inspection with microscopy
  - further measurements
  - discussion with ULM via Michal Ziolkowski

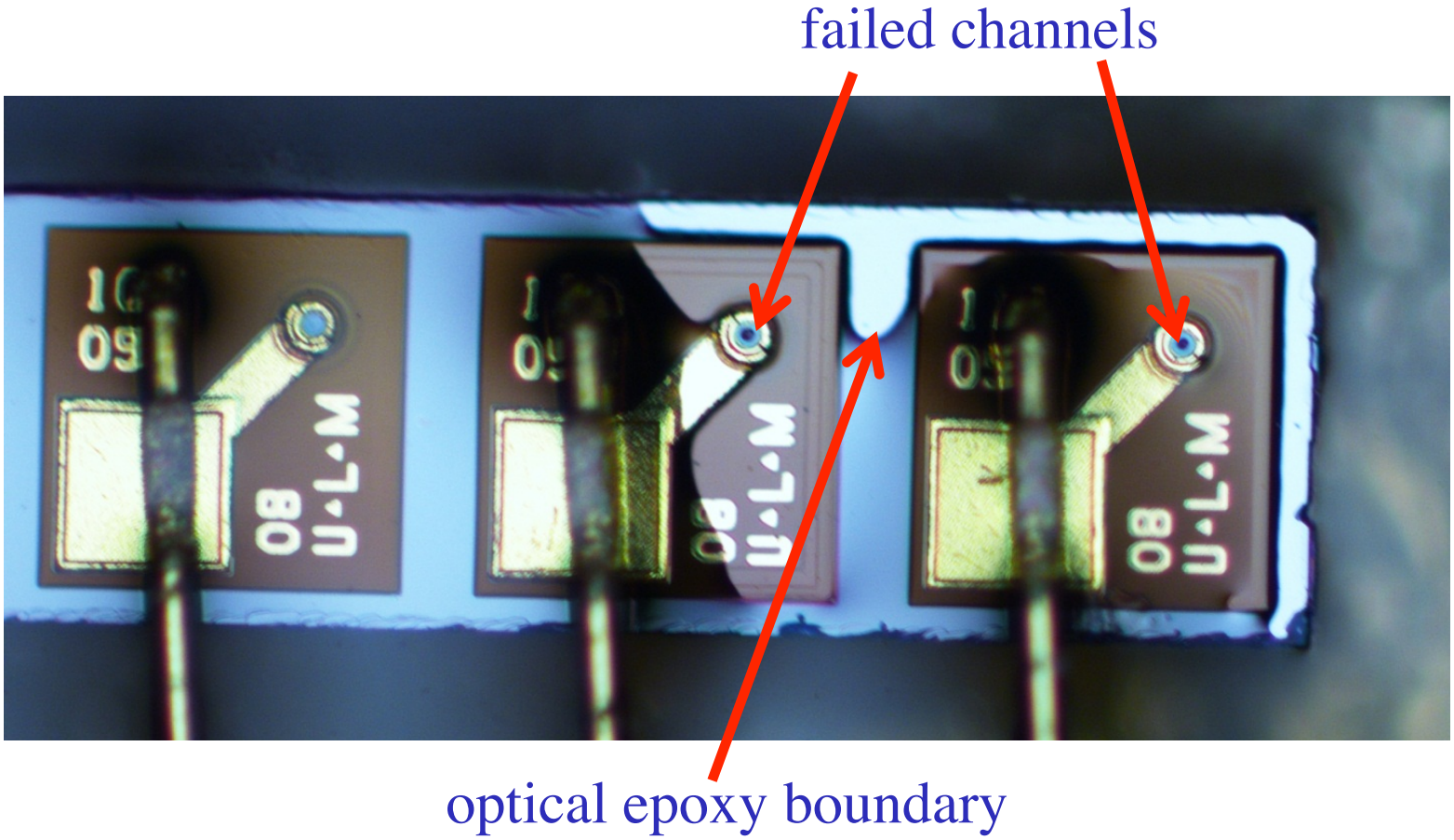
Failure Analysis

- 16 - optical epoxy coverage/scraping
  - including 4 on a cracked die
- 2 - no obvious/correlated cause
  - discolored die
- 2 - ultrasonic cleaning of die before placement
- 1 - broken wire bond during test



Optical Epoxy Coverage Failures

- All channels with incomplete epoxy coverage failed



Optical Epoxy Scraping Failures

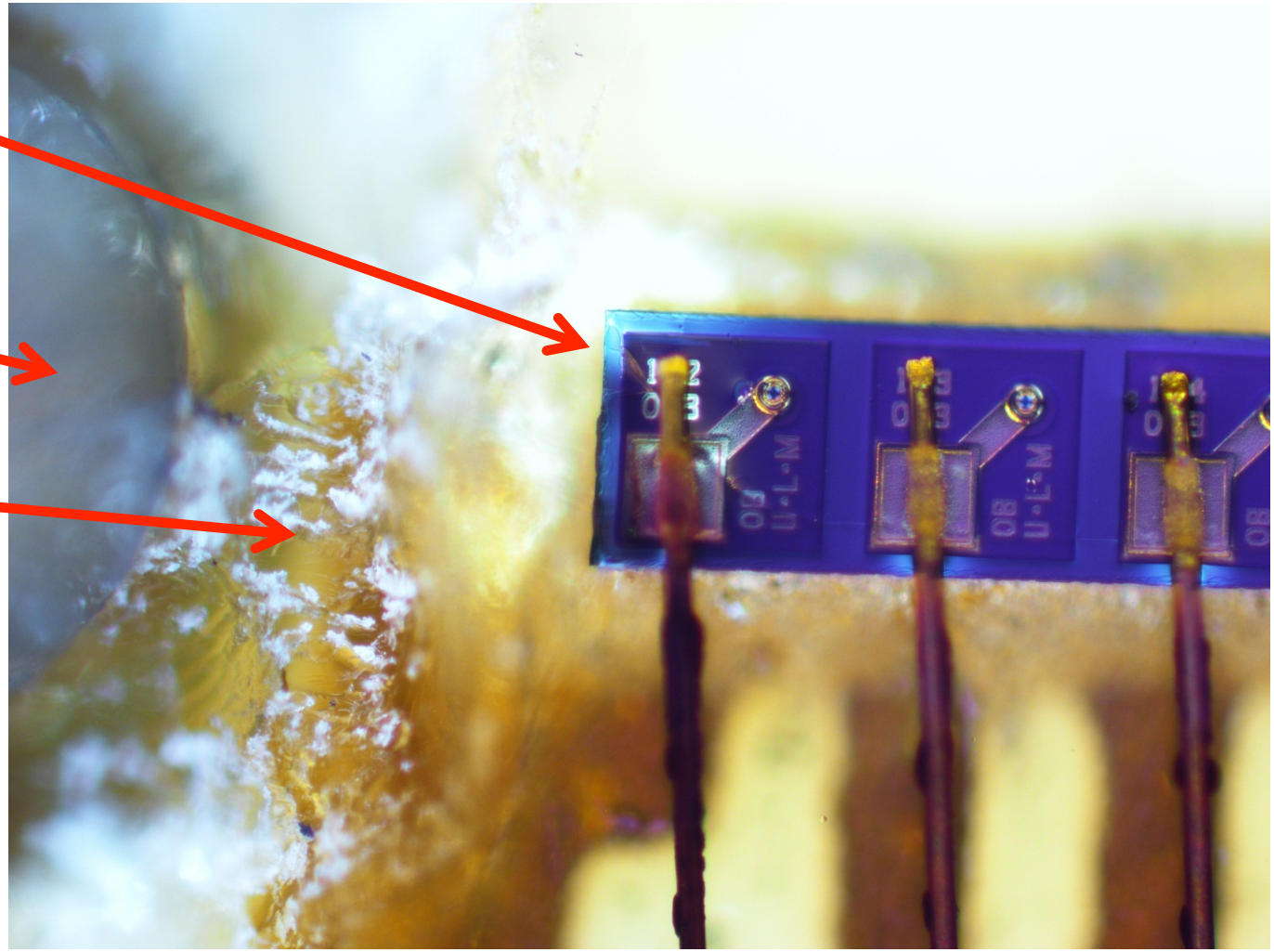
- not possible to have complete epoxy coverage without epoxy around MT guide pins
  - ⇨ epoxy wick up the guide pins due to capillary effect
  - ⇨ scrape epoxy from guide pins to allow proper fiber coupling
  - ⇨ the accelerated lifetime study reveals that this might cause long term reliability issues:
    - ◆ cracked a die (which survived nearly the whole test)
    - ◆ introduced stress in a few arrays

Cracked Die

Crack in die (continues to channel 8)

MT guide pin

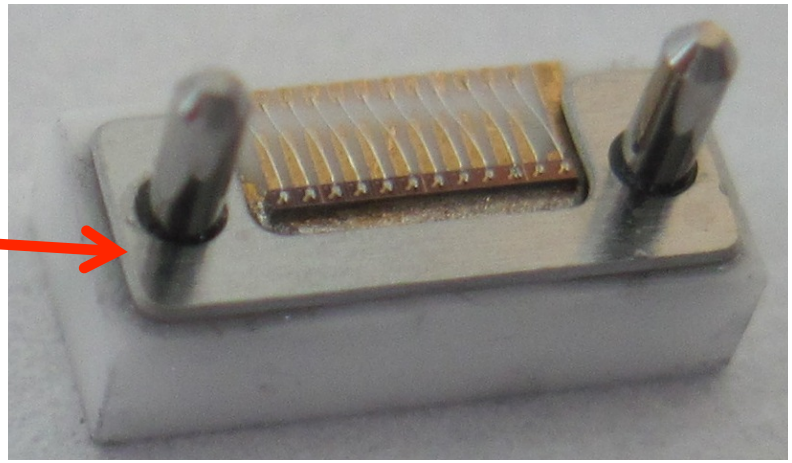
Scraped optical epoxy



Optical Epoxy Solution

- Add an optical epoxy dam
  - keeps epoxy from climbing the MT guide pins
    - ⇨ no optical epoxy scraping
  - adds reservoir to assist in complete epoxy coverage
  - doubles as MT ferrule bumper
- Presently constructing 20 Finisar arrays with the optical epoxy dam for next lifetime test
  - dam successfully tested on two arrays

Optical epoxy dam

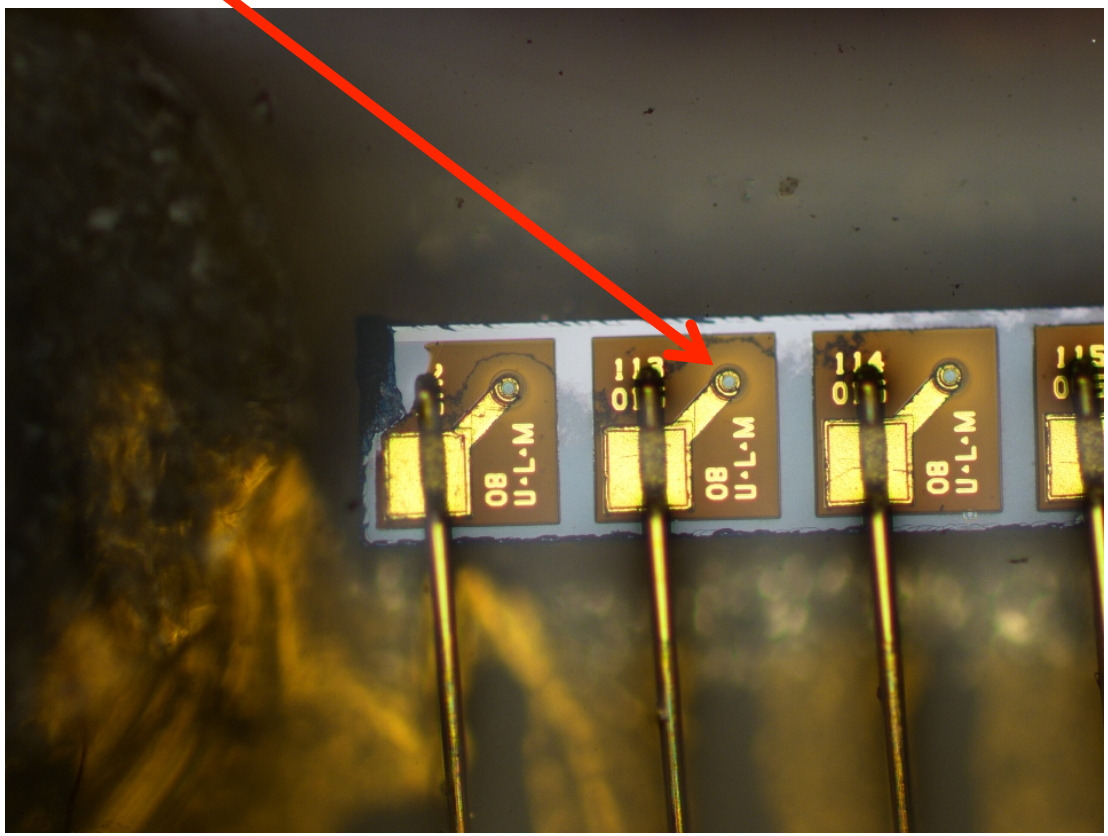


Discolored Die

- Discoloration on the die with a failed channel

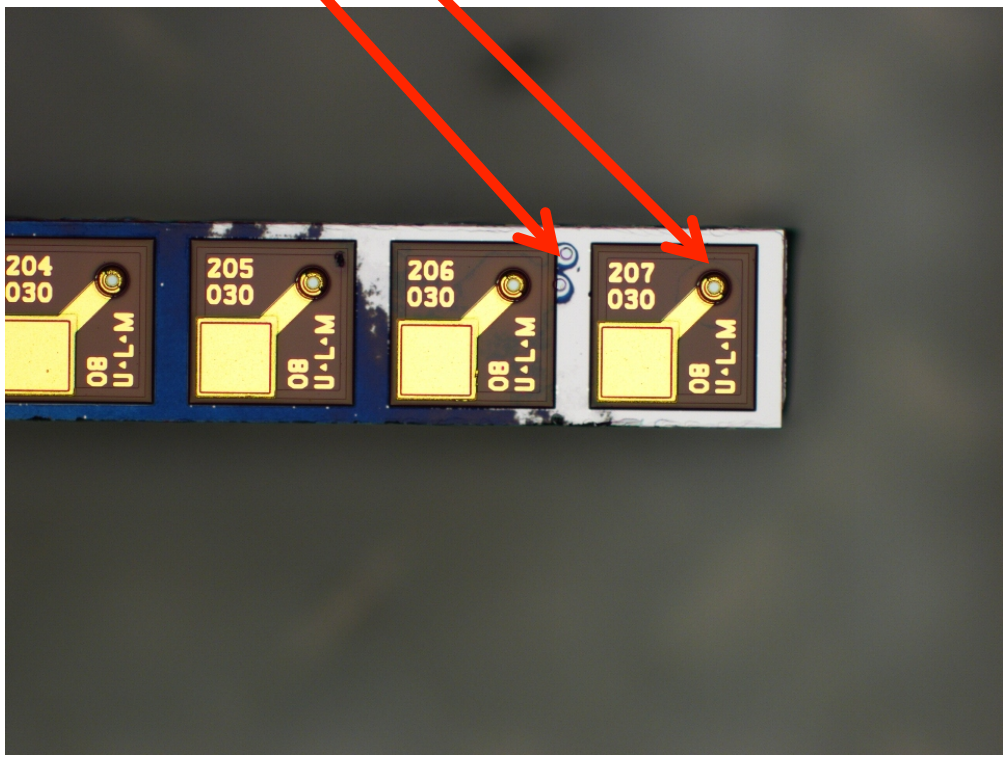
Discolored Die

- This die has discoloration but it passed the 85/85 test
  - ring around the MESA
  - problem with polyimide on channel 1



Unused Die with Discoloration

- Rings around MESA
  - ULM says they are normal
- strange bubble structures
  - present on many dice



Summary

- 20 ULM VCSEL arrays in OSU packages survived 1,000 hrs at 85°C/85% humidity
- Problem with OSU packaging procedure identified (after 1,500 hrs!)
- The accelerated lifetime test was successful
- Constructing 20 improved OSU packages with Finisar arrays for next test
- Why are unused ULM die discolored?