



ULM 10 Gb/s VCSEL Array Accelerated Lifetime Study

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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

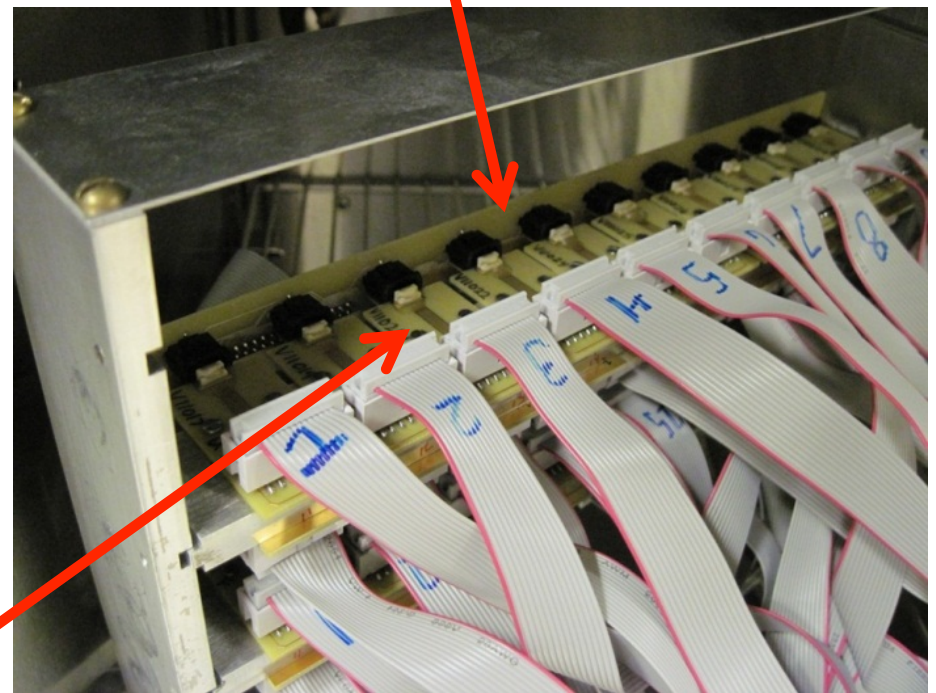


Test Setup

Environmental chamber



Wide area photo-diode mounting card



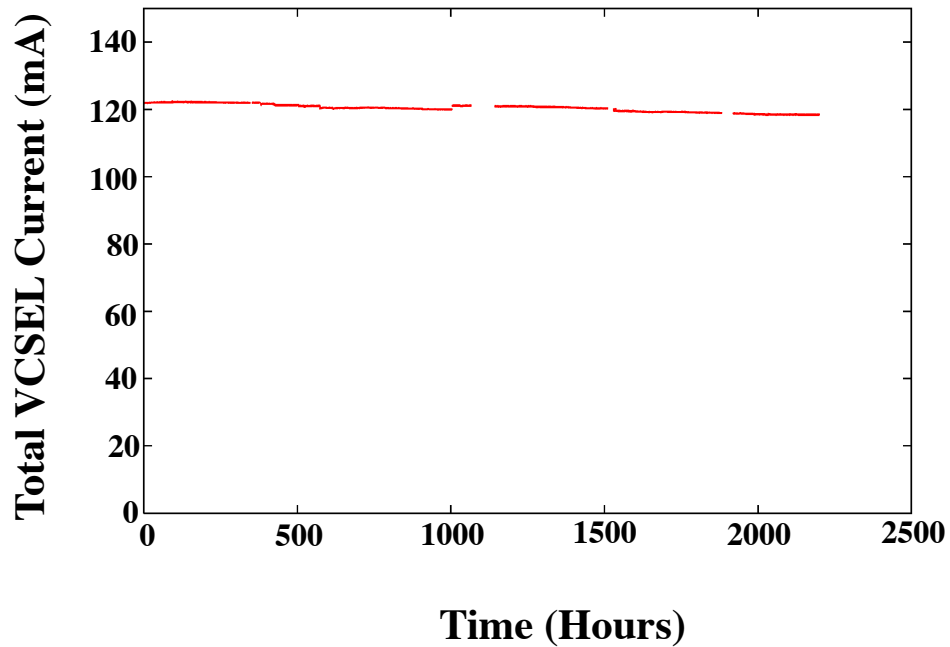
Single array test card



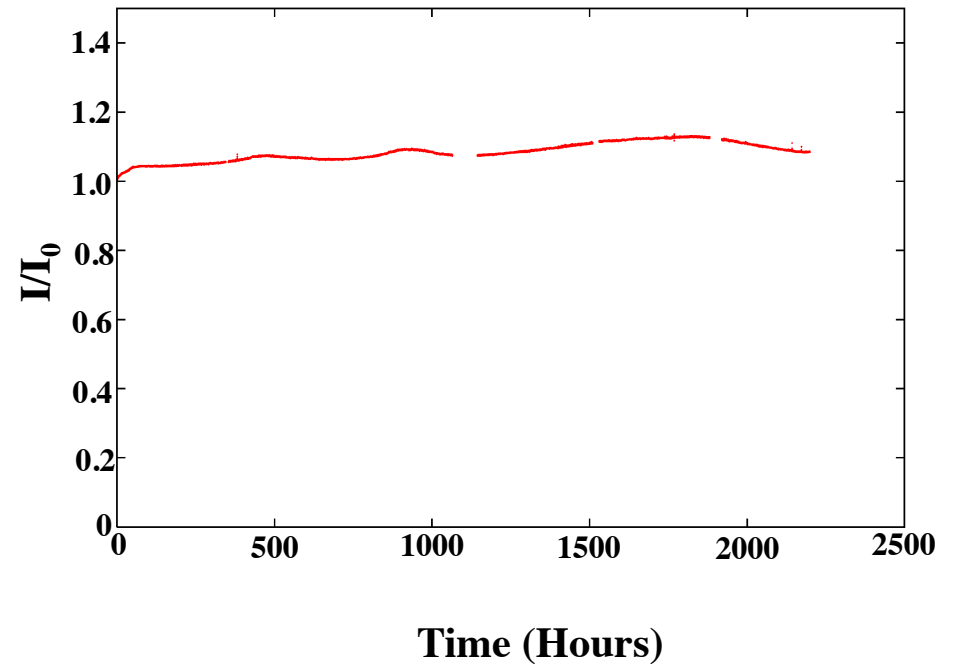
VCSEL Current/Power

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

V11022 ULM VCSEL 8585 Test



V11022 ULM VCSEL 8585 Test

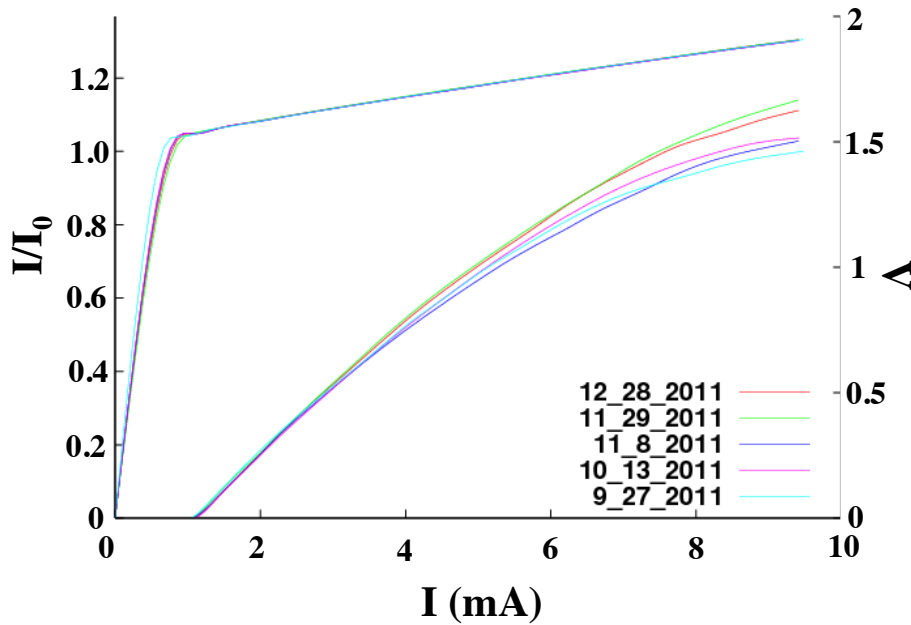




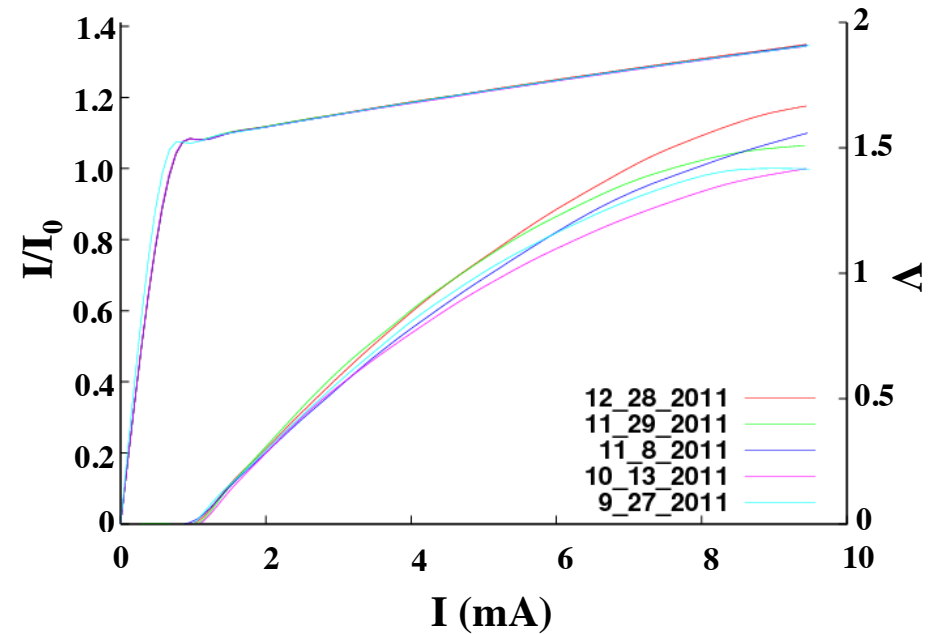
LIV Measurements

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

V11022 Channel 1



V11022 Channel 2

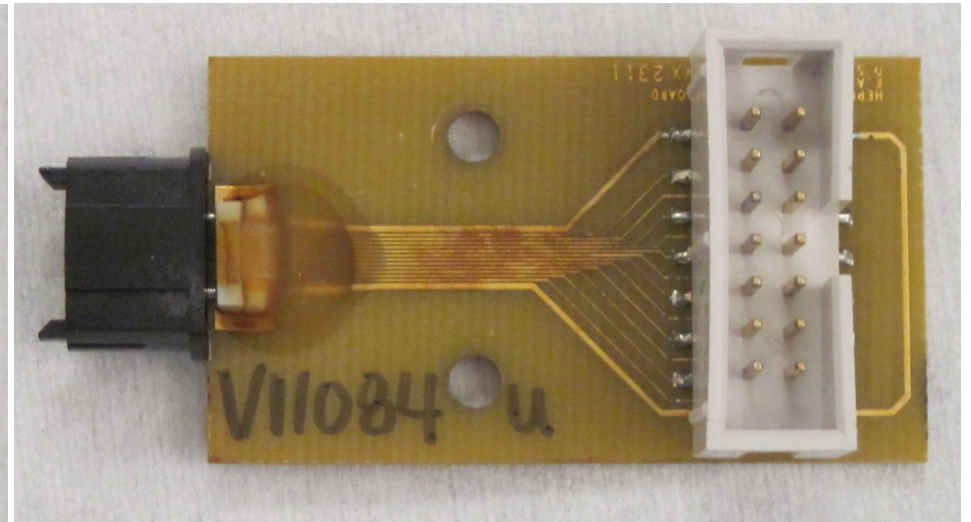
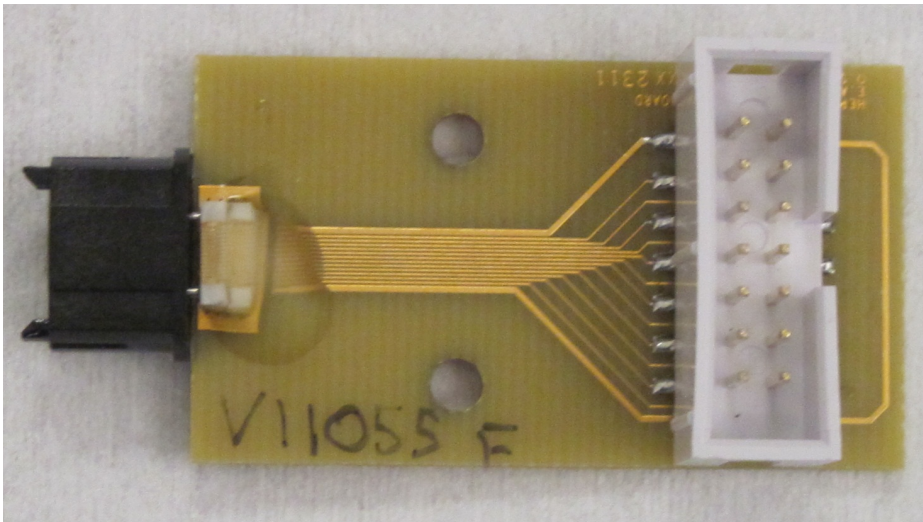




Visible Effects of 85/85 Test

Untested array/PCB
room temp/humidity

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





Results

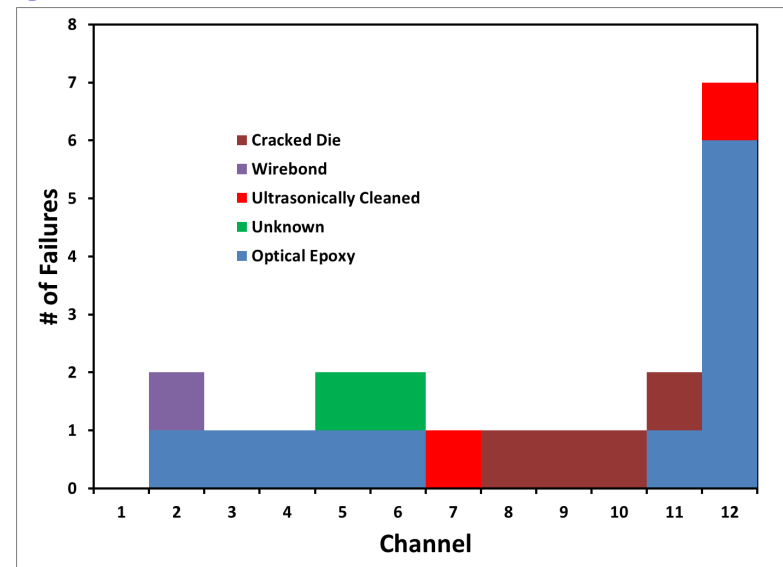
Hours	Failed Channels
1,002	0
1,510	2
2,200	19

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



Failure Analysis

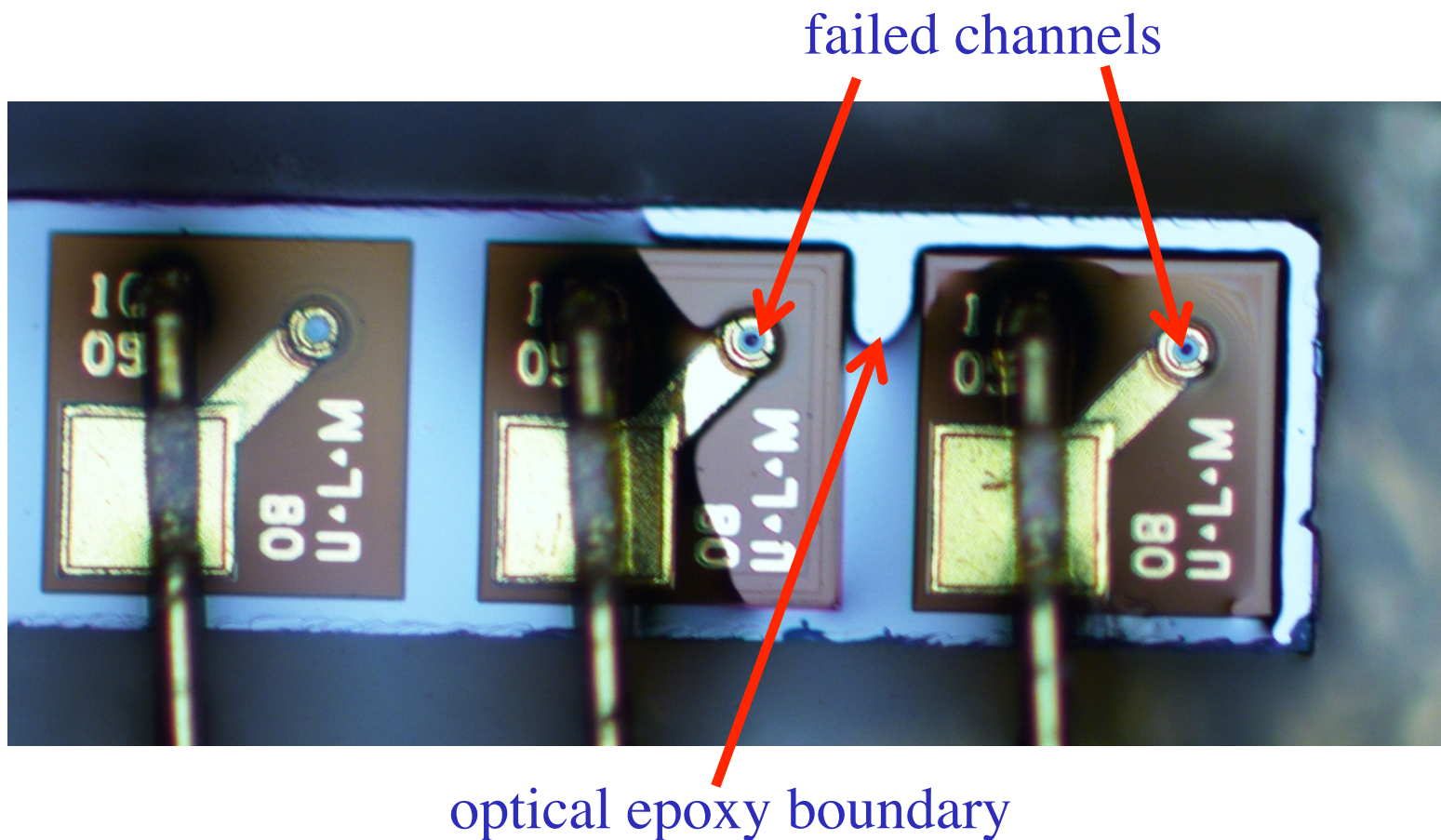
- 16 - optical epoxy coverage/scraping
 - ◆ including 4 on a cracked die
- 2 - no obvious/correlated cause
 - ◆ discolored die
- 2 - ultrasonic cleaning of die before placement
- 1 - broken wire bond during test





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

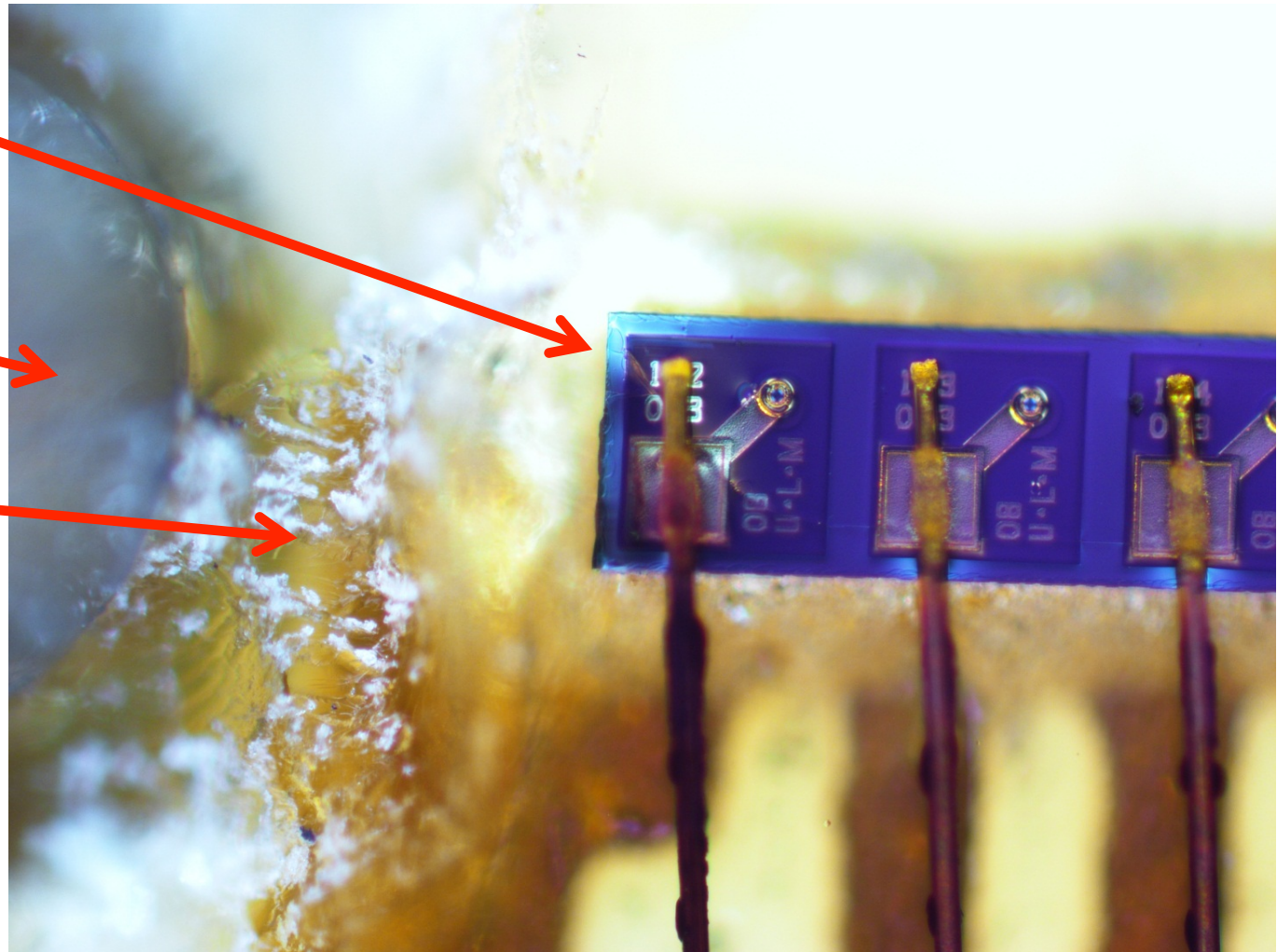


Cracked Die

Crack in die
(continues to
channel 8)

MT guide pin

Scraped
optical epoxy

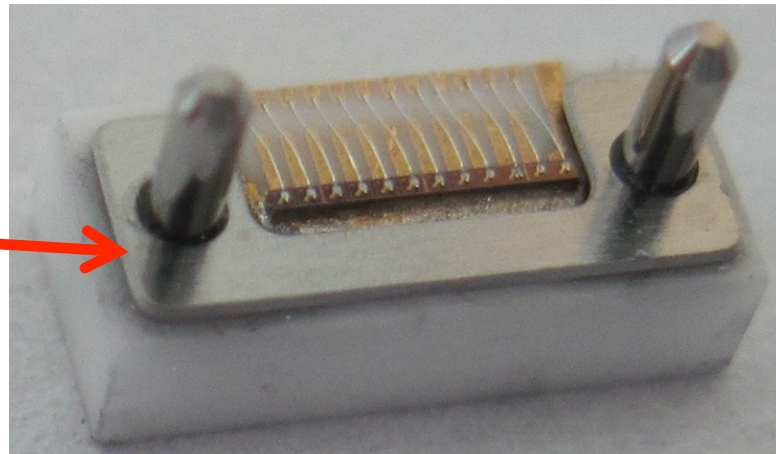




Optical Epoxy Solution

- 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

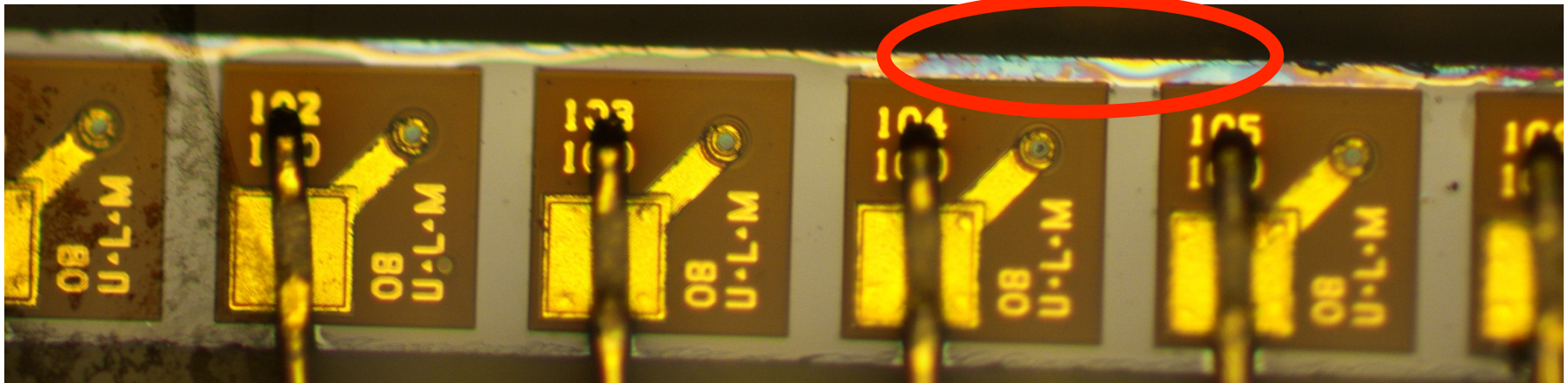
Optical epoxy
dam





Discolored Die

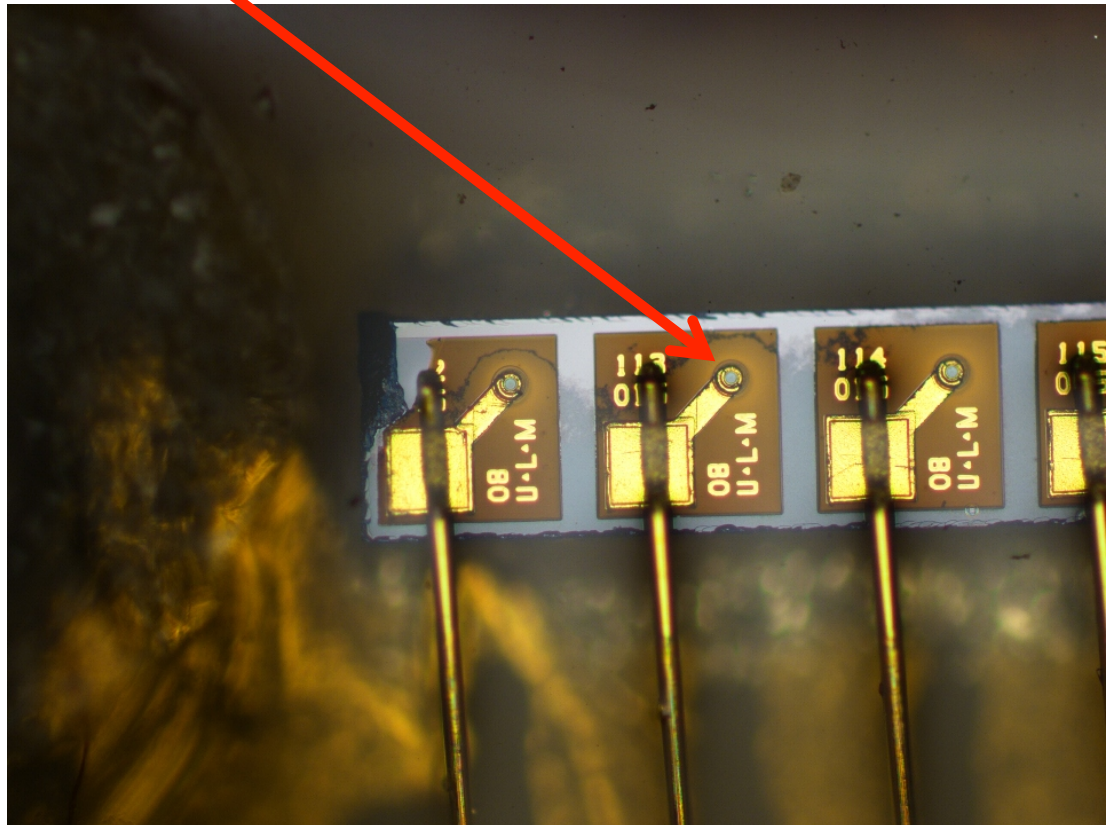
- Discoloration on the die with a failed channel





Discolored Die

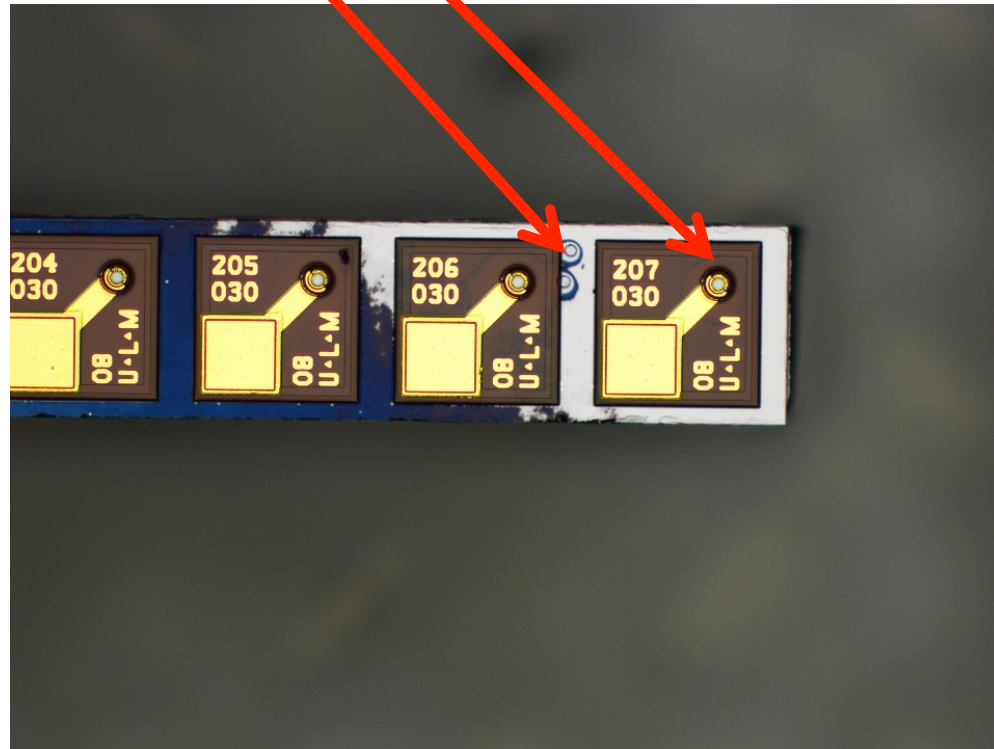
- This die has discoloration but it passed the 85/85 test
 - ◆ ring around the MESA
 - ◆ problem with polyimide on channel 1





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?