
EIGHTEENTH ANNUAL
BiTS
TM
Burn-in & Test Strategies Workshop
March 5 - 8, 2017
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive – Session 7
© 2017 BiTS Workshop – Image: tonda / iStock

# Copyright Notice

Session 7
Morten Jensen
*Session Chair*

BiTS Workshop 2017 Schedule

# Solutions Day

Wednesday March 8 - 8:00 am

## Teaming Up

**"Applying FEA Simulation for Test Interface Unit"**
Jason Koh - Test Tooling Solutions Group

**"BI RHINO Handling Solution"**
Yaniv Raz- Intel Corporation

**"Optical Device Testing at Wafer Level and Package Devices"**
Carl Kasinski – Aehr

**"Fan-in WLCSP Test Requirements"**
Mike Frazier - Mike Frazier

# Optical Device Testing at Wafer and Package Level

Carl Kasinski
Aehr Test Systems

BiTS Workshop
March 5 - 8, 2017

# The Optical Device Market

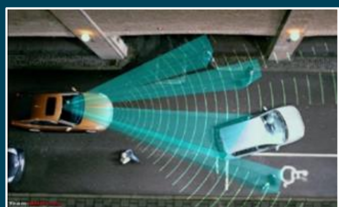
Areas of optical device market growth:

- Automotive sensors
- Smartphone optical sensors
- Gesture recognition and 3D sensing for home entertainment
- Data Communications
- Security applications
- General lighting applications
- Optical and Laser mice applications

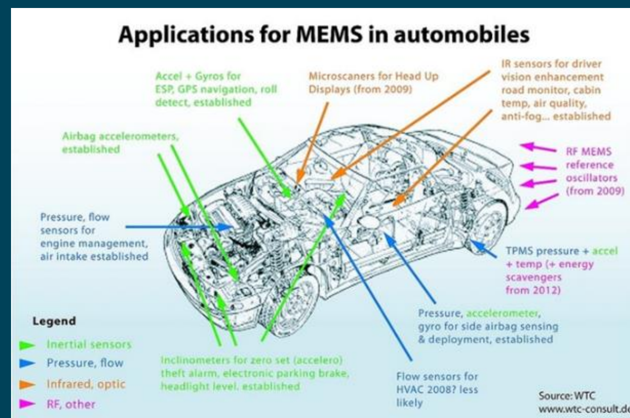
# Automotive Device Market

Automotive optical sensors:

- Collision detection sensors (LIDAR)
  - High power IR laser diodes – up to 300’ coverage
- On-board computer control with gesture recognition
  - Low power IR LEDs – up to 3’ coverage







# Smartphone Device Market

Smartphone optical sensors:

- Proximity sensors for screen disabling and backlight reduction when near the human ear
  - Low power IR LEDs – up to 3” coverage
- Gesture recognition for screen control
  - Low power IR LEDs – up to 3’ coverage


# Home/Business Device Market

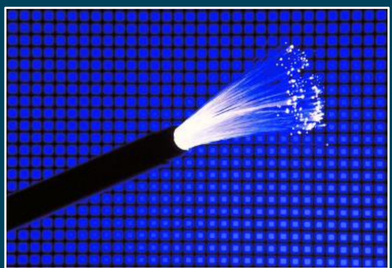
Gesture recognition and 3D sensing:

- Gesture control of computers, home appliances, entertainment (TV set-top boxes,…)
- High power IR laser diodes – up to 30' coverage

# Data Communication Market

Data Communications:

- More than 500 million VCSELs used for high speed communications in the past 15 years
- Signal integrity requires VCSEL aging to ensure reliable and optimal performance



850nm Multi Mode SFP
Fiber Optical Transceiver

According to Zion Research, in 2015 the global vertical-cavity surface-emitting laser (VCSEL) market accounted for around $760 million with VCSELs in cars and data centers expected to drive the market's CAGR to ~21% eventually reaching $2,400 million by 2021.

# Additional Optical Device Markets

- Optical security applications
- General lighting applications
- Optical and laser mice applications


# Optical Device BI / Aging Needs

| Optical Device Markets | Poor Reliability Impact | Replacement Cost | Burn-in / Aging |
|---|---|---|---|
| Automotive sensors for collision detection | ● ● ● ● | ● ● ● ● | Yes |
| Automotive gesture recognition | ● ● ● | ● ● ● ● | Yes |
| Smartphone gesture recognition | ● ● ● | ● ● ● | Yes |
| Home gesture recognition & 3D sensing | ● ● ● | ● ● ● | Yes |
| Data communications | ● ● ● ● | ● ● ● | Yes |
| Security applications *(Passive)* | ● ● ● | ● ● | No |
| General lighting Optical/laser mice for PCs | ● | ● | No |

# Optical Device Burn-in

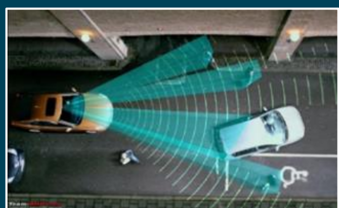
Burn-in (BI) vs. Aging:

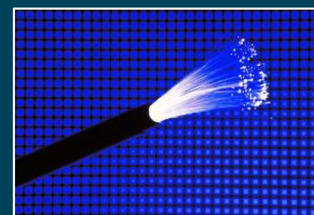
- Burn-in screens for early life failures
- Aging achieves device parameter stabilization
- Use "burn-in" to identify either since challenges and techniques are similar

Optical device burn-in:

- For fiber optical devices - attenuation, insertion loss and changes in dispersion characteristics may appear during the early staging of the burn-in process

# Targeted Burn-in Solutions

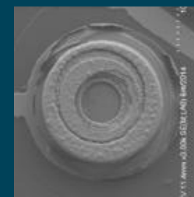


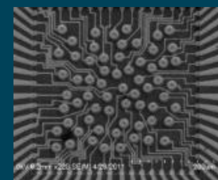


# Targeted BI Solution Challenges

Automotive collision LIDAR (Light Detection and Ranging) and office/home gesture recognition sensors:

- <u>High power</u> constant current source (FI) for VCSEL arrays and voltage source (FV) for logic in modules
- High power density / heat dissipation / light output measurement





Automotive and smartphone gesture recognition sensors:

- <u>Medium power</u> FI for VCSEL/LED and FV for logic in modules
- Very small packages / medium heat dissipation / light output

Data communications:

- <u>Medium power</u> VCSEL / medium heat dissipation / light output

# Multi-Site Device Power Options

Use individual or shared power supplies

Supply current to multiple DUTs:

- Option 1: Large bulk supply shared
- Option 2: Individual current supply per DUT

Supply voltage to multiple DUTs:

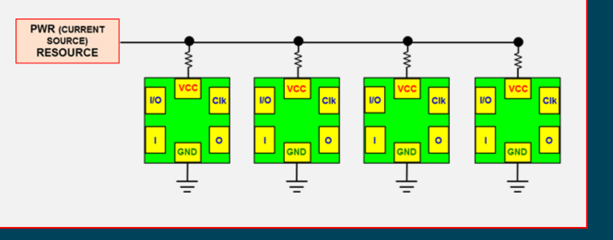
- Option 1: Large bulk supply shared
- Option 2: Individual voltage supply per DUT

# Multi-Site Device FI Options

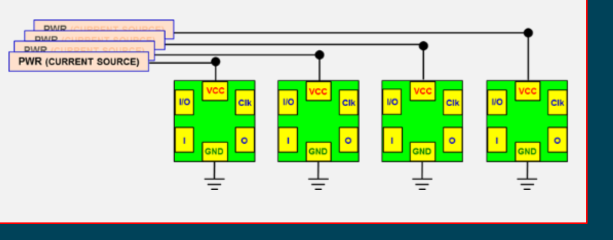
## Use individual or shared current supplies

Supply current to multiple DUTs:

- Option 1: Shared bulk supply
  - Ganged current forcing
  - No per DUT measurement




- Option 2: Individual supply per DUT
  - Individual constant current source
  - Per DUT measurement

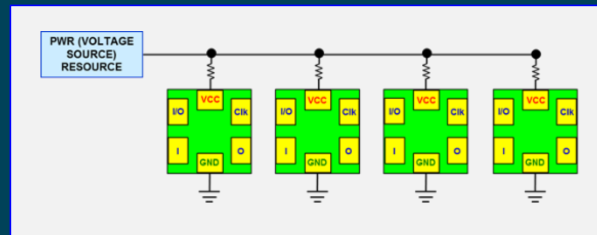


## Multi-Site Device FV Options

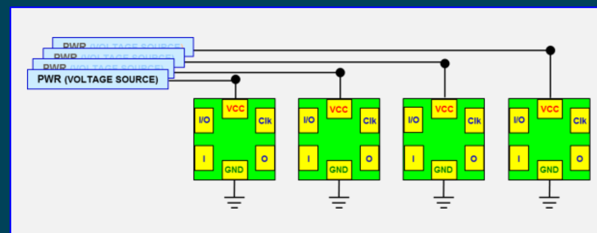
Use individual or shared voltage supplies

Supply voltage to multiple DUTs:

- Option 1: Shared bulk supply
  - Common forcing voltage
  - No per DUT measurement




- Option 2: Individual supply per DUT
  - Individual voltage source
  - Per DUT measurement



# Voltage Source Comparison

Voltage source shared by DUTs:

- **Pro:** Resource and layout simplification
- **Con:** No per DUT FV calibration
- **Con:** No per DUT current measurement
- **Con:** "Hostage failures" possible when group member fails

Individual voltage source per DUT:

- **Pro:** Enables individual DUT FV control and measure current
- **Feature Reqmts:** 100s of supplies needed
- **Feature Reqmts:** Capable of 50 mA to >1 A as required

# Current Source Comparison

Large current source shared by DUTs:

- **Pro:** Simplifies resource requirements
- **Con:** No per DUT current sourcing
- **Con:** "Hostage failures" possible when group member fails

Individual constant current source per DUT:

- **Pro:** Individual DUT current sourcing
- **Pro:** Prevents "hostage failure" yield loss
- **Feature Reqmts:** 100s of current supplies needed
- **Feature Reqmts:** Capable of 1-4 amps as required

# Powering Multiple VCSEL Devices

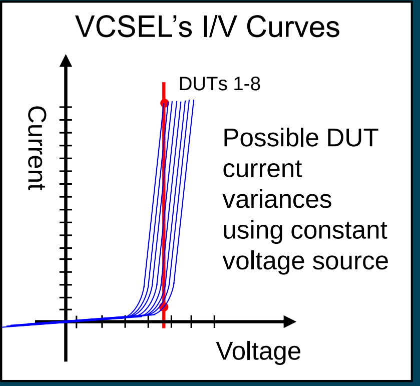
## Shared power vs. unique constant current sources

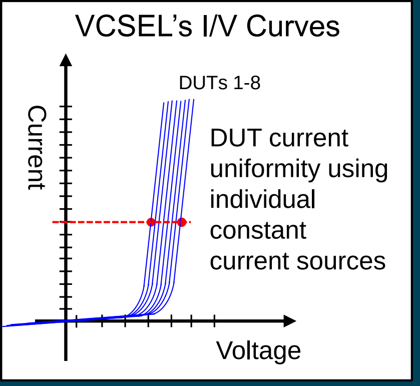
Shared voltage supply:

- VCSEL's currents/power vary widely for chosen voltage
- BI time defined by lowest power VCSEL

Individual constant current supply/DUT:

- VCSEL's current/power closely matched
- Balanced VCSEL power minimizes required BI time



# Recommended VCSEL Power Solution

Individual voltage and constant current sources

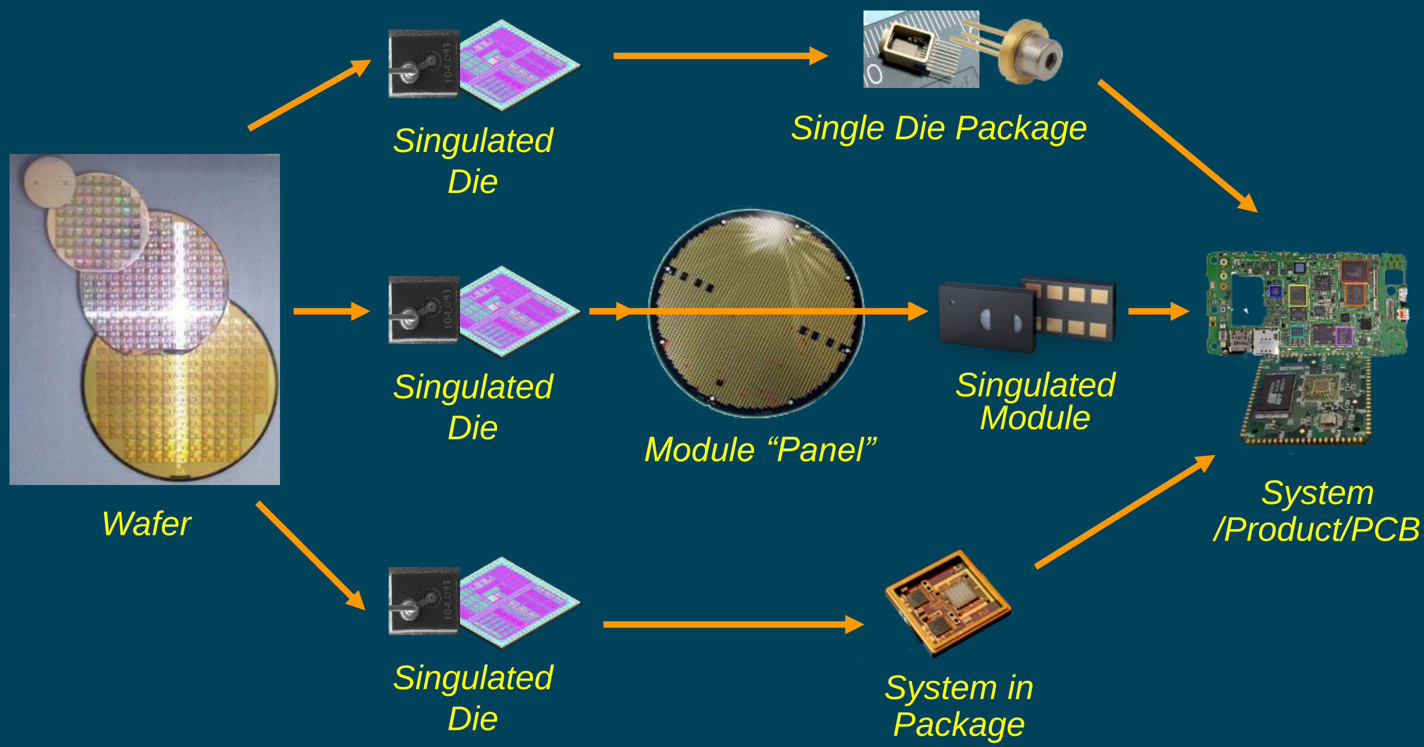
Voltage source (FV) capabilities:

- >1,000 FV supplies for high parallelism
- Voltage supply for VCSEL module logic circuitry
- Current measurement per VCSEL module

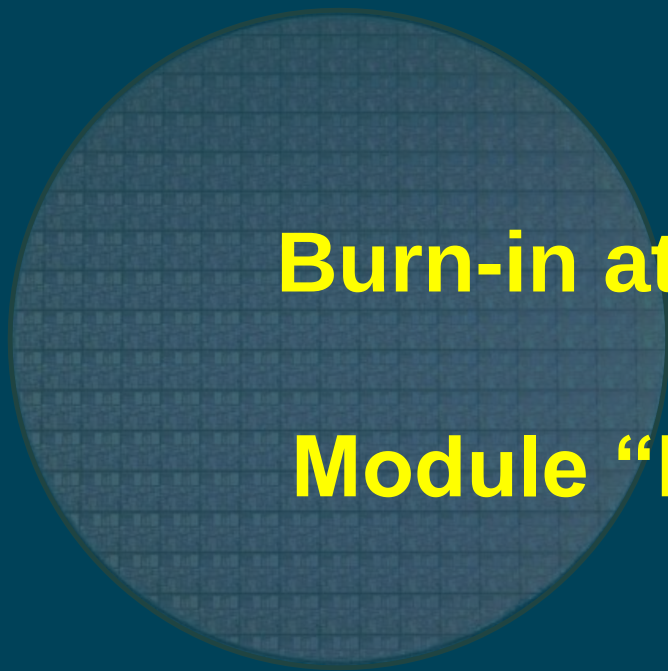
Constant current source (FI) capabilities:

- >1,000 FI supplies enabling high parallelism
- High power capable - up to 4 amps per VCSEL array
- Minimizes “hostage failure” yield loss
- Balances VCSEL power to minimize BI time

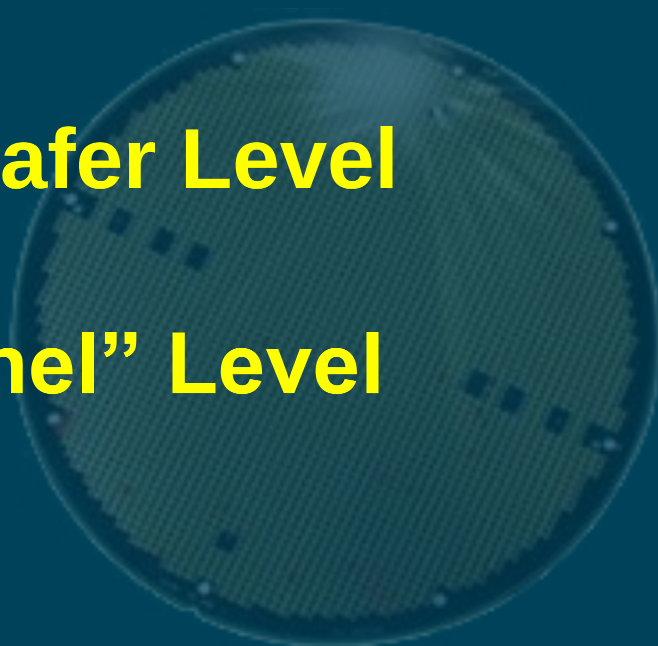
# Production Burn-in Options



# Burn-in at Wafer Level
# or
# Module "Panel" Level



*Wafer*



*Module "Panel"*

# Wafer / Module "Panel" BI Systems

Require the following capabilities:

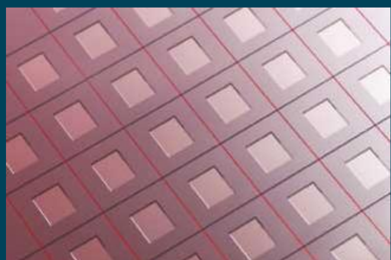
- Full wafer / module panel pads contacted - 100s to 1,000s of contact pins
- 1,000s of FV and FI supplies
- 1,000s of I/O resources for digital test if required
- DUT temperature stability control:
  - Pad to contact alignment maintained at burn-in cycling (CTE matching of materials)
  - Capable of heating or removing device generated heat uniformly across wafer / module panel (maintaining junction temperature requirements)

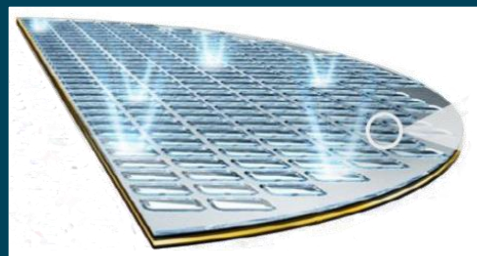
# Wafer / Module “Panel” BI Systems

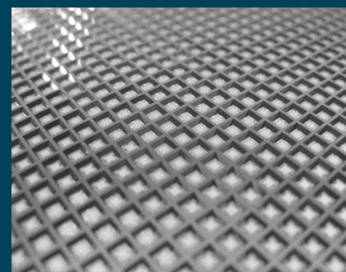
Additional Module “Panel” BI system challenges

Module “Panel” may have irregular surface:

- Contactors must compensate with longer contact pin stroke
- Heating/cooling uniformity across irregular surface



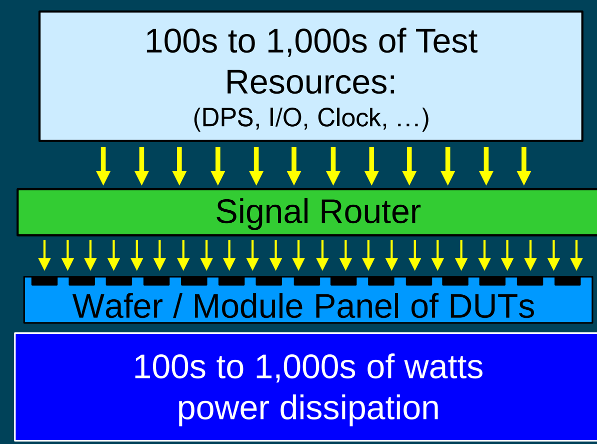




# Wafer/Panel Burn-In

Burn-in test system with the following capabilities:

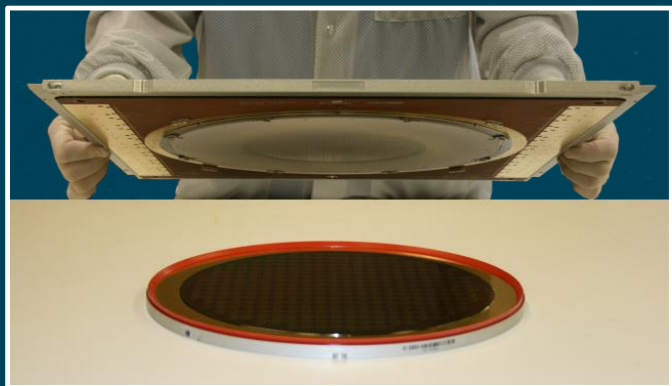
- Accommodate 4”–12” wafers or module “panels”
- Burn-in/test varied substrates: Si/GaAs/AlGaAs/GaN/…
- Handle various panel substrate materials and very high compliance requirements (panel bow in mms)
- Deliver high power and remove excessive heat energy
- Supply contact force to 100s – 10,000s of pads on wafer or module “panel”

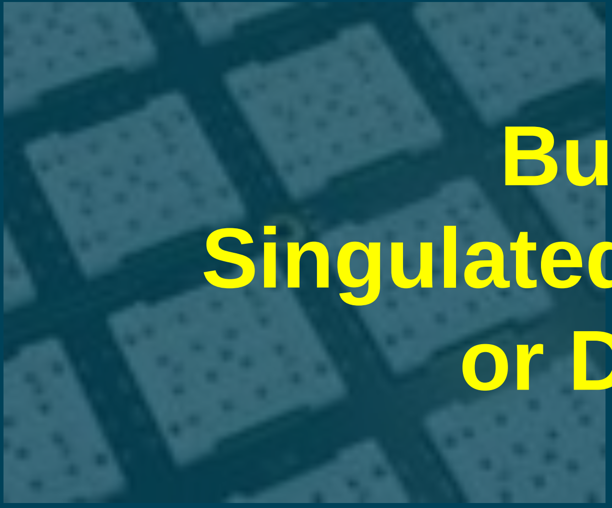


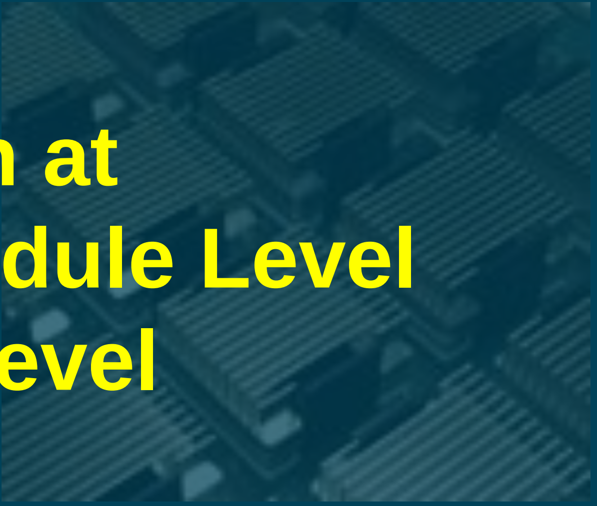
# Wafer Burn-In Example

## Reusable WaferPak™ Cartridge

- Supports up to 2,048 (I/O or DPS) resources per wafer
- Vacuum actuation
- Aehr Test ThinChuck™ thermal chuck (capable of up to 2 kW / wafer)
- Reusable for multiple wafer types





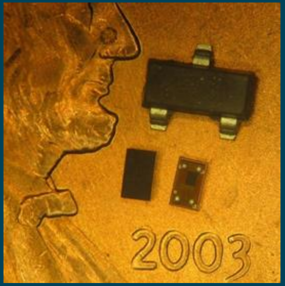


# Burn-in at Singulated Module Level or Die Level

# Singulated Module/Die Burn-in Systems

Require the following capabilities:

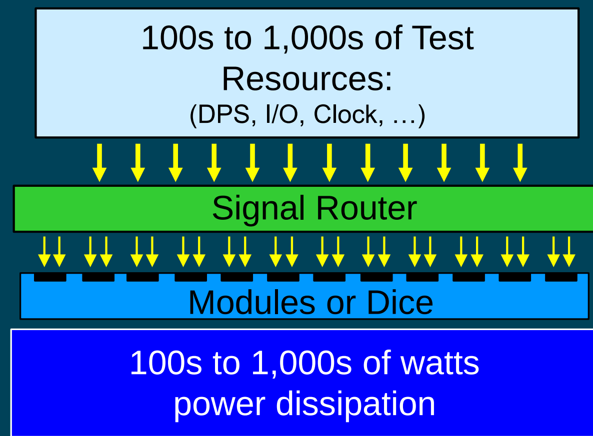
- Base capabilities of Wafer / Module “Panel” BI system
- Ability to handle/fixture of 2-15 mm$^2$ chip scale packages (CSP)
- Hybrid air/liquid cooling or heating for optical energy and device temperature stability
- I/O resources for module digital logic testing
- Optical measurement capability built into module/die socket
- Massive parallelism for cost-effective production BI

# Singulated Module/Die Burn-in

Burn-in test system with the following capabilities:

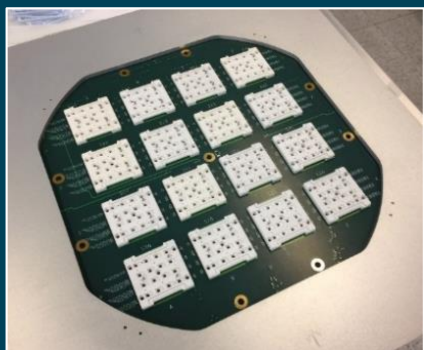
- Accommodate 100s of modules/dice per burn-in/test board
- Address very small die / CSP module pad contact requirements
- Solve module/die socketing challenges
- Measure optical light energy of individual dice/modules
- Maintain tight thermal control of heat generated by device and optical light energy

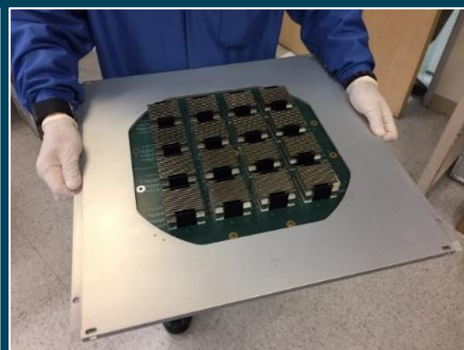


# Module/Die Burn-In Example

## Reusable DiePak® Carrier

- Supports up to 2,048 (I/O or DPS) resources per burn-in/test board
- Aehr Test ThinChuck™ thermal chuck (capable of up to 2 kW / wafer)





# Summary

High power VCSEL and integrated VCSEL modules presents unique BI challenges for the optical device market

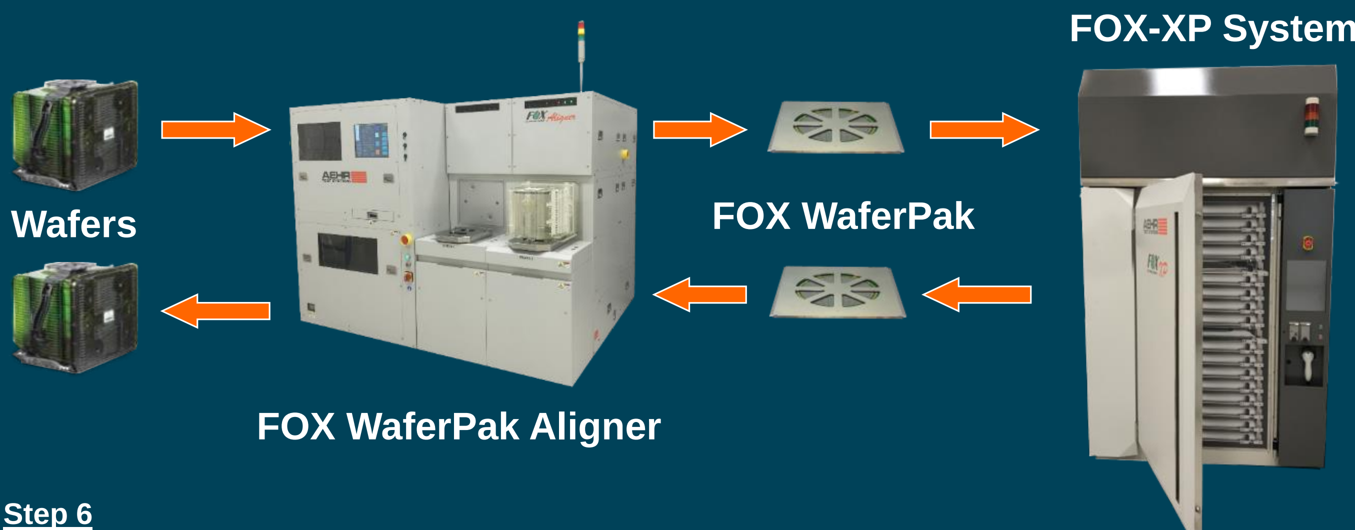
- Volume production BI of high power VCSELs may require 1,000 FI supplies per BI slot (wafer / module “panel” / singulated module or die)
- Device heat energy must be controlled – maintaining the correct BI cycling temperature requirement
- Mechanical contact with device pads must remain aligned through temperature cycling to 125°C or greater
- Digital logic in module may require stimulus/test during BI
- Optical measurement of the VCSEL light output may be required

# Wafer Level Production Flow

**Step 1**
Cassette with wafers placed onto Aligner

**Step 2**
Automated loading/alignment of wafer into WaferPak

**Step 3**
WaferPak loaded into system




**Step 6**
Burned-in wafers removed from WaferPak Aligner and returned to Cassette

**Step 5**
Automated unloading of wafer from WaferPak

**Step 4**
WaferPak removed with burned-in wafers

# Module Level Production Flow

**Step 1**
JEDEC Tray with devices placed into Pick & Place Autoloader

**Step 2**
Automated loading of devices into DiePak

**Step 3**
DiePak loaded into system


**Step 6**
Burned-in devices removed from Autoloader in JEDEC Trays

**Step 5**
Automated unloading of devices from DiePak

**Step 4**
DiePak removed with burned-in devices

# Conclusion

Volume production BI of high power VCSELs can be cost-effective with the following system emphasis:

- High parallelism is paramount – wafer level BI or 1000s of DUTs per system BI is needed for a viable COT
- Individual constant current sources are required
- High power VCSELs necessitate stringent temperature control – air and liquid cooling is essential
- Digital I/O resources may be required for VCSEL modules with digital logic cells
- CTE effects should always be considered at BI temperatures