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# Towards automated manufacturing of fiberized Butterfly modules

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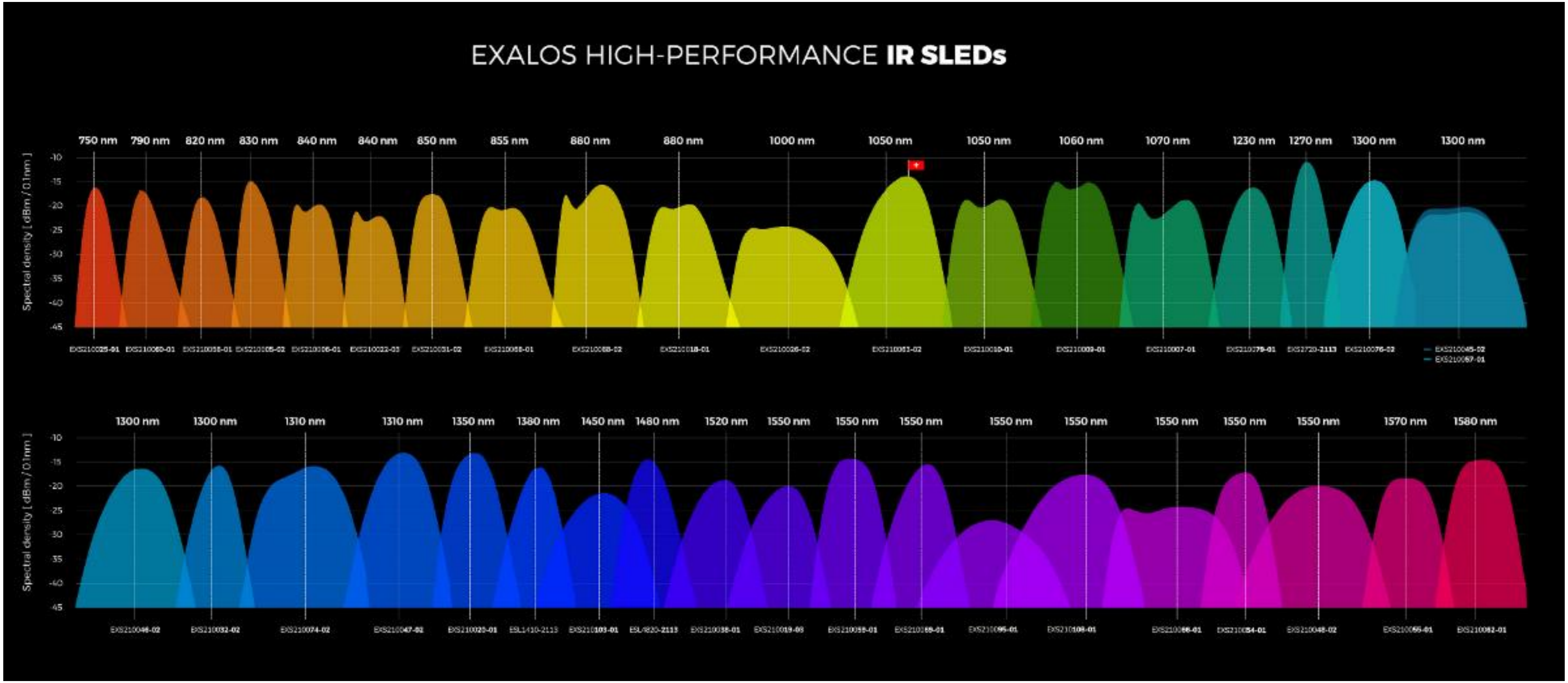
# BROADBAND SUPERLUMINESCENT DIODES (SLEDs)



➔ we are offering SLED devices from 400nm to 1700nm

EXALOS
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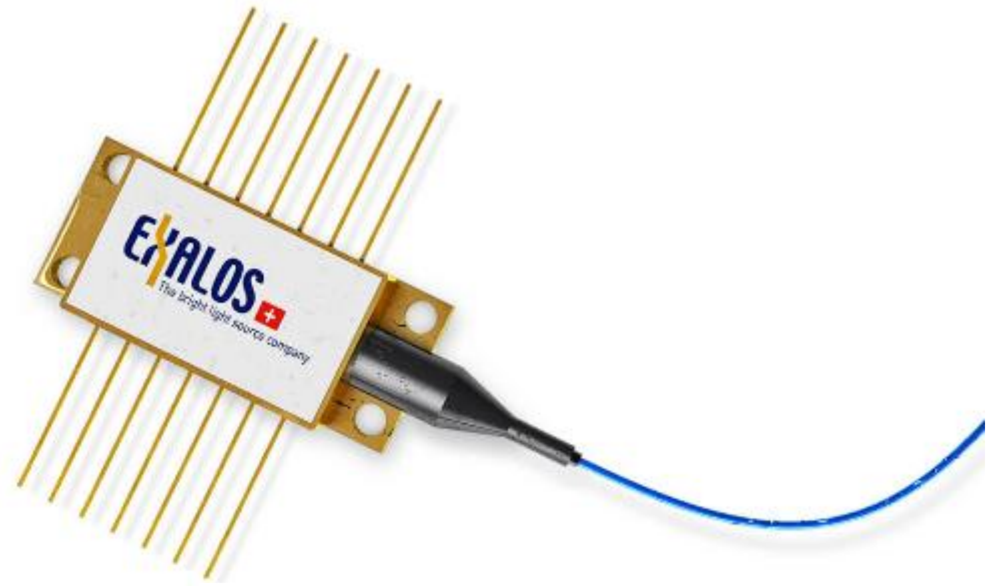
# OUR PRODUCTS

- We mainly sell SLED devices in the form of optical modules,
  e.g., 14-pin Butterfly modules with single-mode or PM output fibers



- Fiber coupling is done with lensed fibers or free-space optics using
  - Laser welding
  - Metal soldering
  - Glass soldering

subcontracted to external packaging suppliers

  - Epoxy-based attachment of micro-optics

in-house, only for advanced light sources

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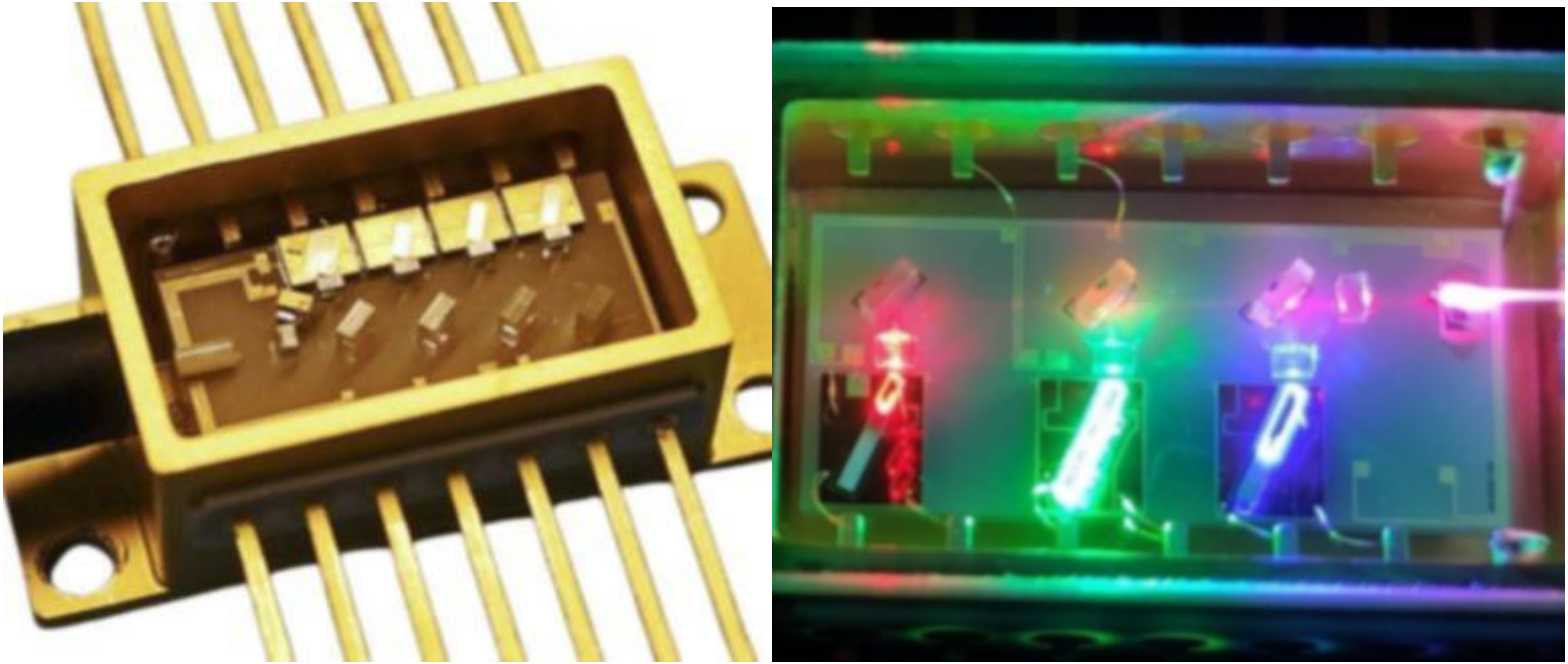
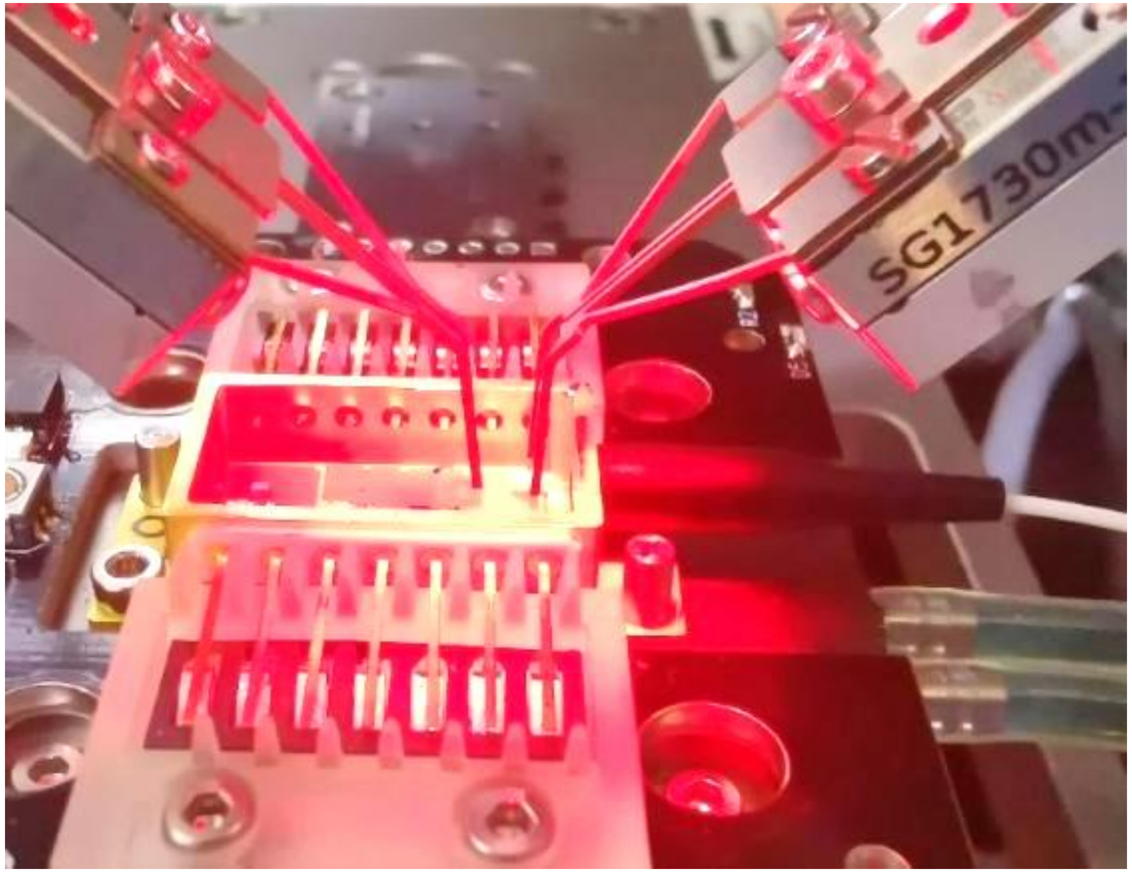
# EXAMPLES OF MICRO-OPTICAL INTEGRATION

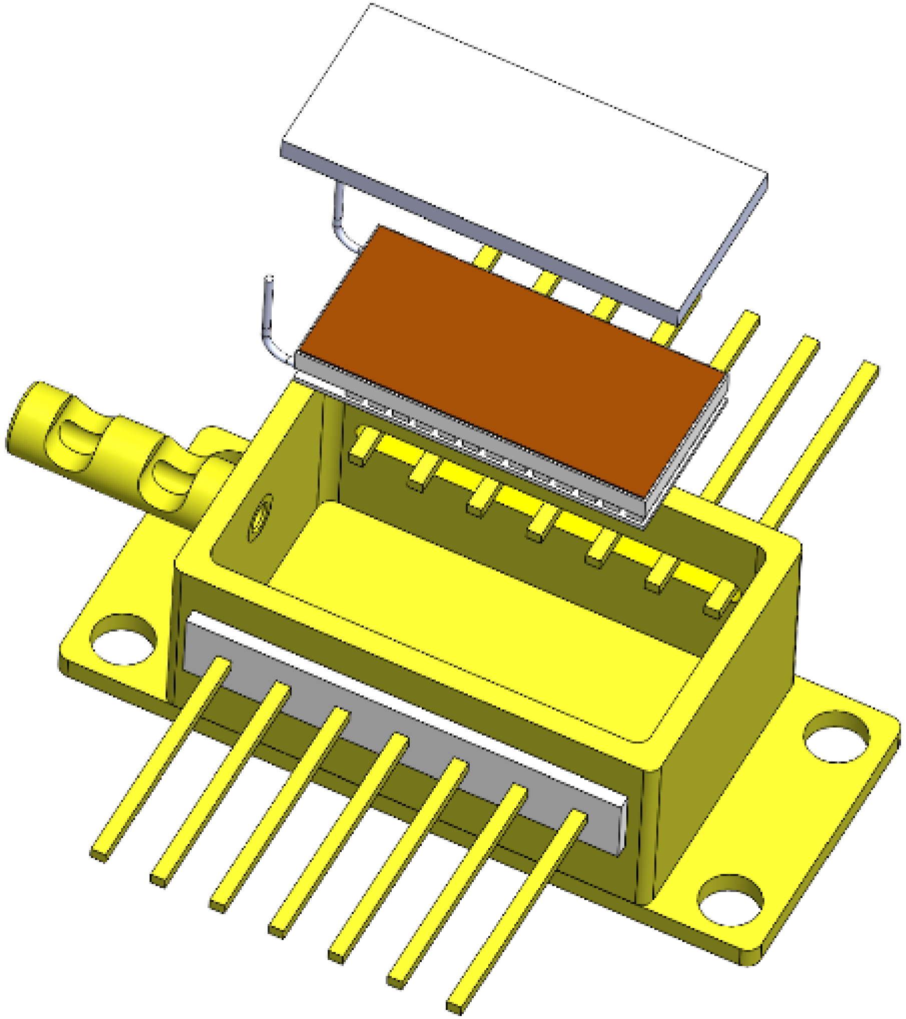


# AUTOMATED FREE-SPACE ALIGNMENT & PACKAGING



Micro-optical integration in use @ EXALOS since 2008 !

# BUTTERFLY PRE-ASSEMBLY (MANUAL)



- Peltier cooler (TEC) and optical bench (ceramic) are soldered into the 14-pin Butterfly module
- Batch process, i.e., several Butterfly modules are assembled at the same time
- Preparation of modules and execution of process is manual !

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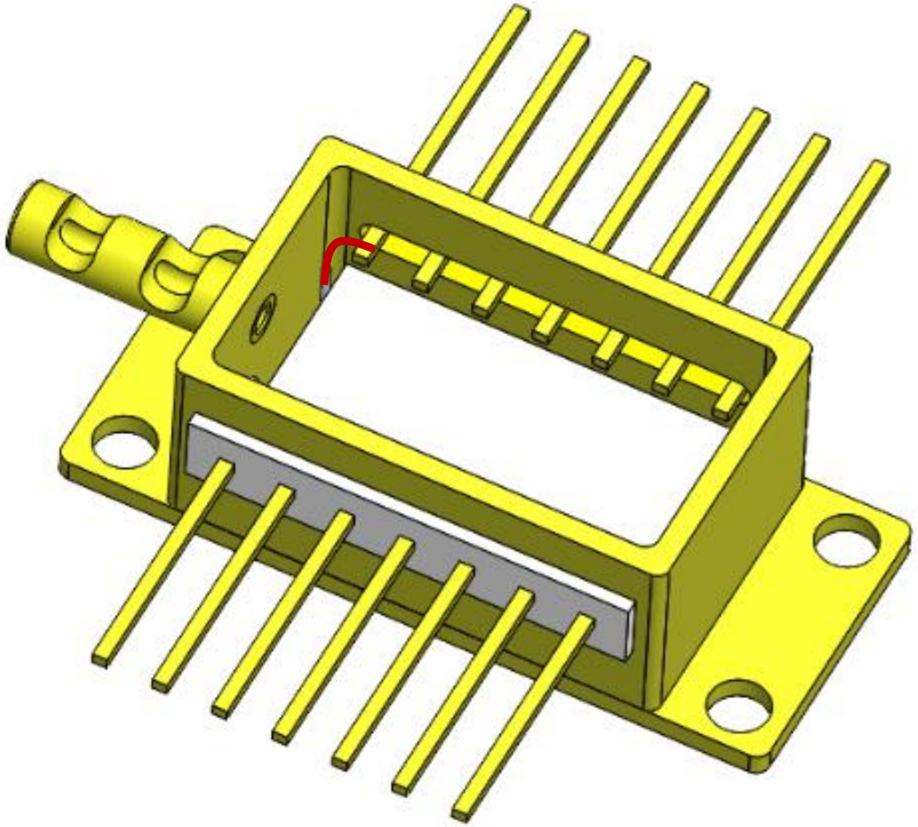
# TEC WIRE ATTACHMENT (MANUAL)



- The two TEC wires are attached to pins of the Butterfly housing
- Manual process !
- There are TECs that allow for (automated) wire-bonding but such designs might be restrictive with the available space for the optical bench or the maximum TEC currents

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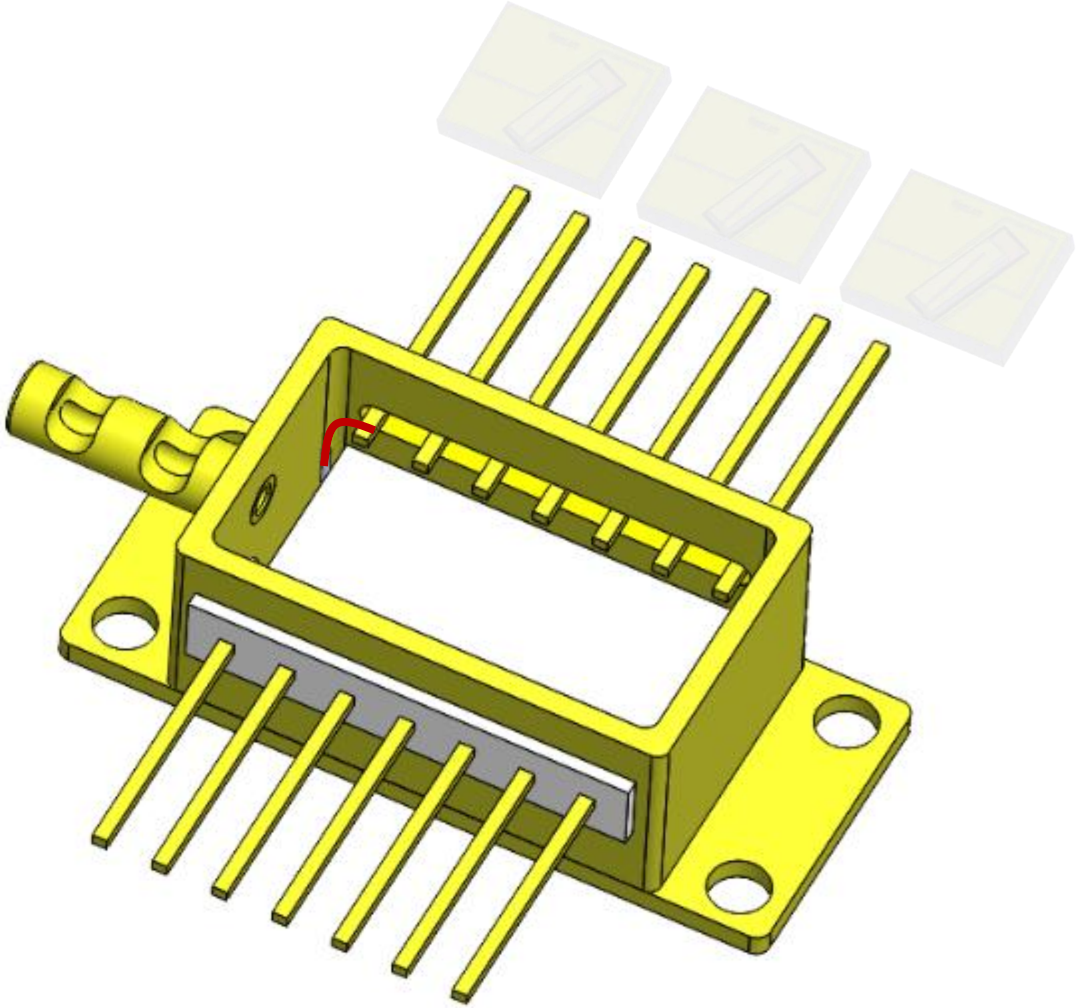
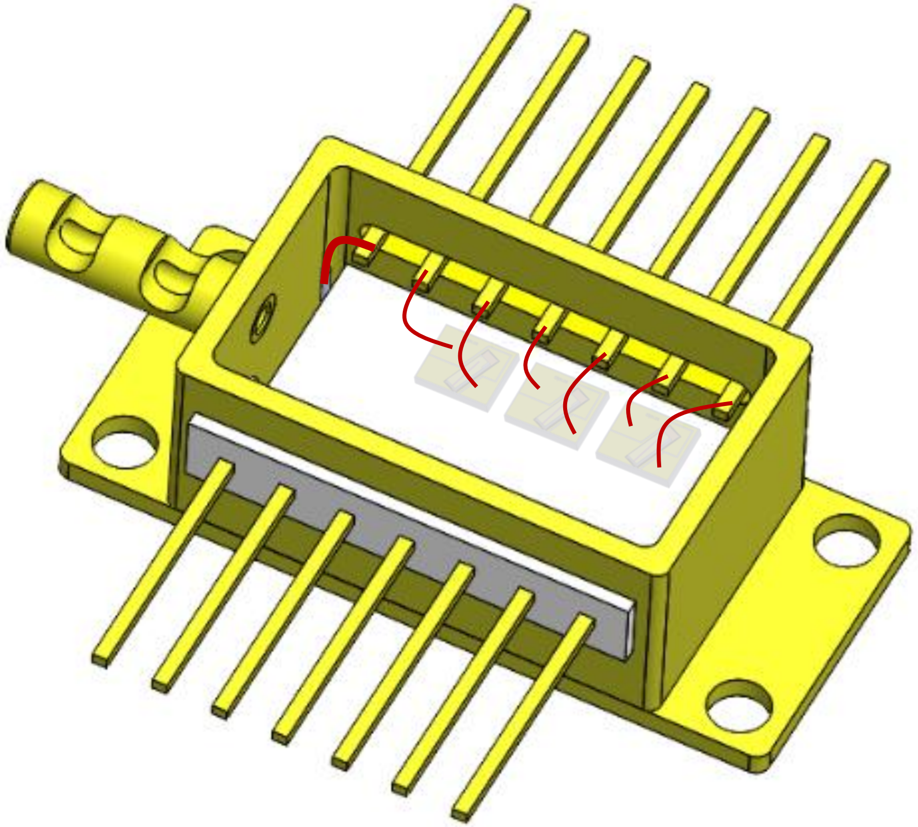
# CHIP-ON-SUBMOUNT PLACEMENT (AUTOMATED)



- The chip-on-submount (CoS) devices are precisely placed with an automated alignment machine onto the optical bench
- Automated attachment based on automated silver epoxy dispensing with automated high-temp curing
- Problem: limited shelf time of silver epoxies (few hours) prevent long automated processes (e.g., over the weekend, during the night, etc.) !

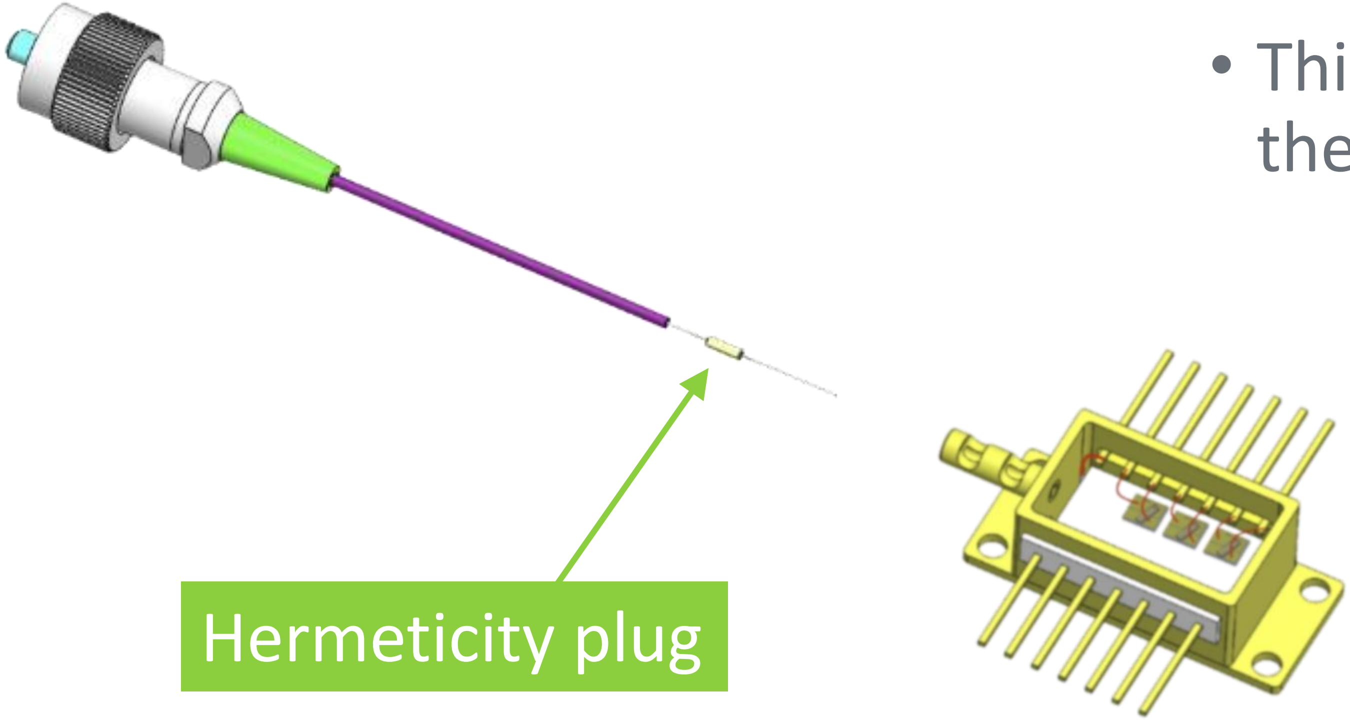
# WIRE BONDING (AUTOMATED)



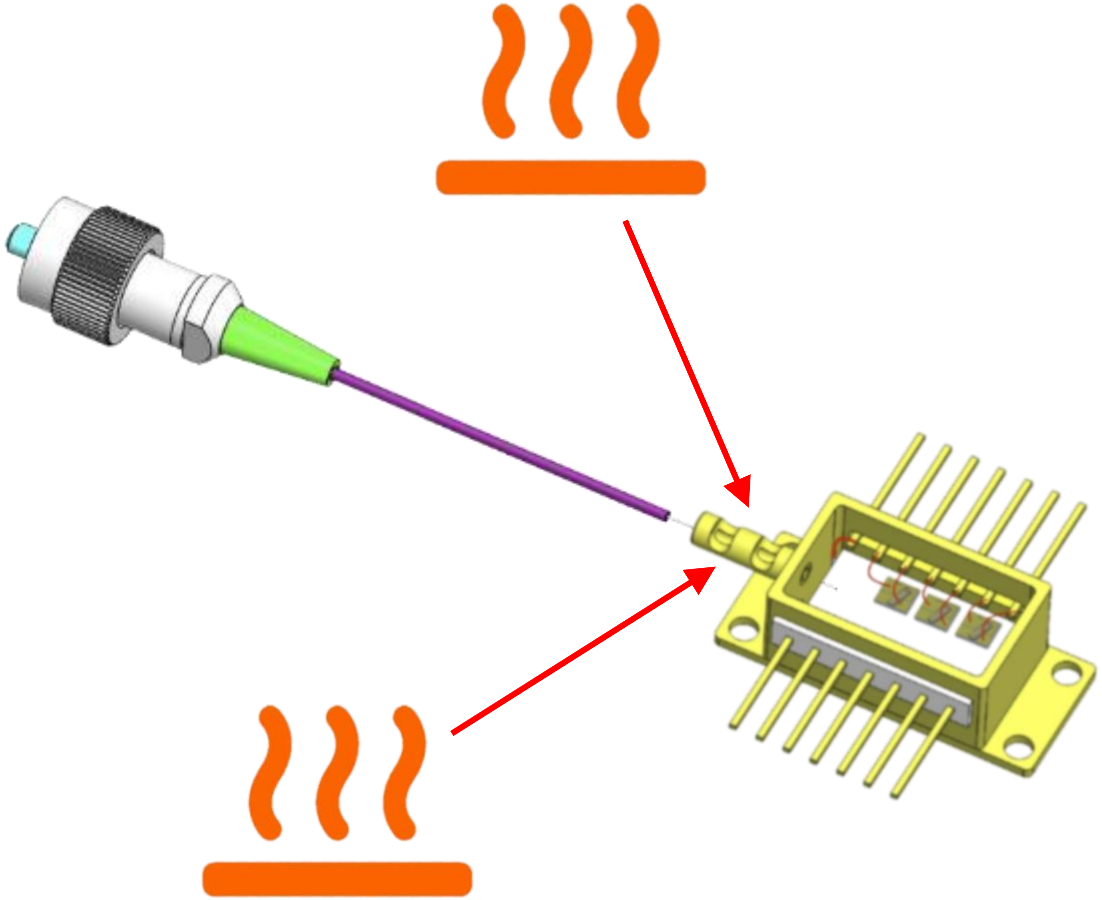
- Active elements (light sources, photodetectors, etc.) are connected to the pins of the Butterfly module with an automated wire bonder

# FIBER FEEDTHROUGH (MANUAL)

- Feeding the fiber pre-assembly through the snout of the Butterfly module is *today* a manual process
- This process shall be automated in the near future …

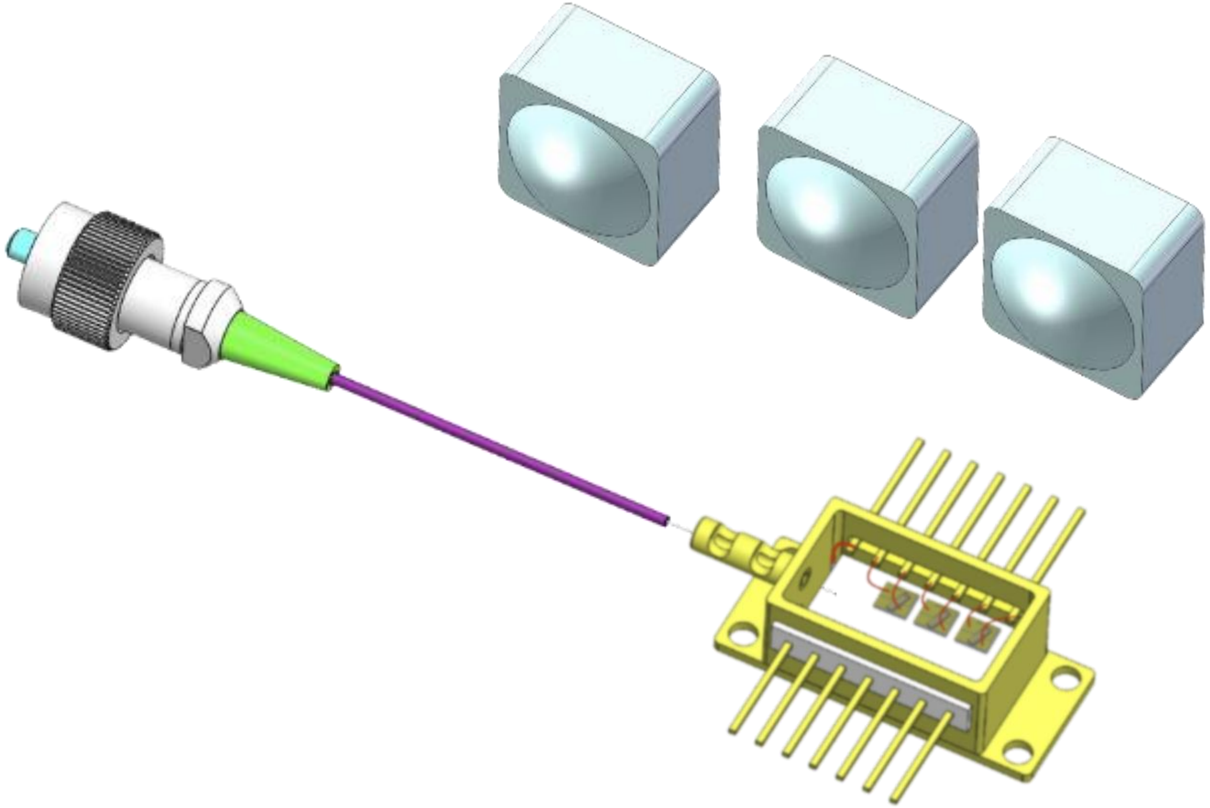


# HERMETICITY PLUG SOLDERING (MANUAL)



- Soldering the hermeticity plug into the snout of the Butterfly module is *today* a manual process
- This process shall be automated in the near future …

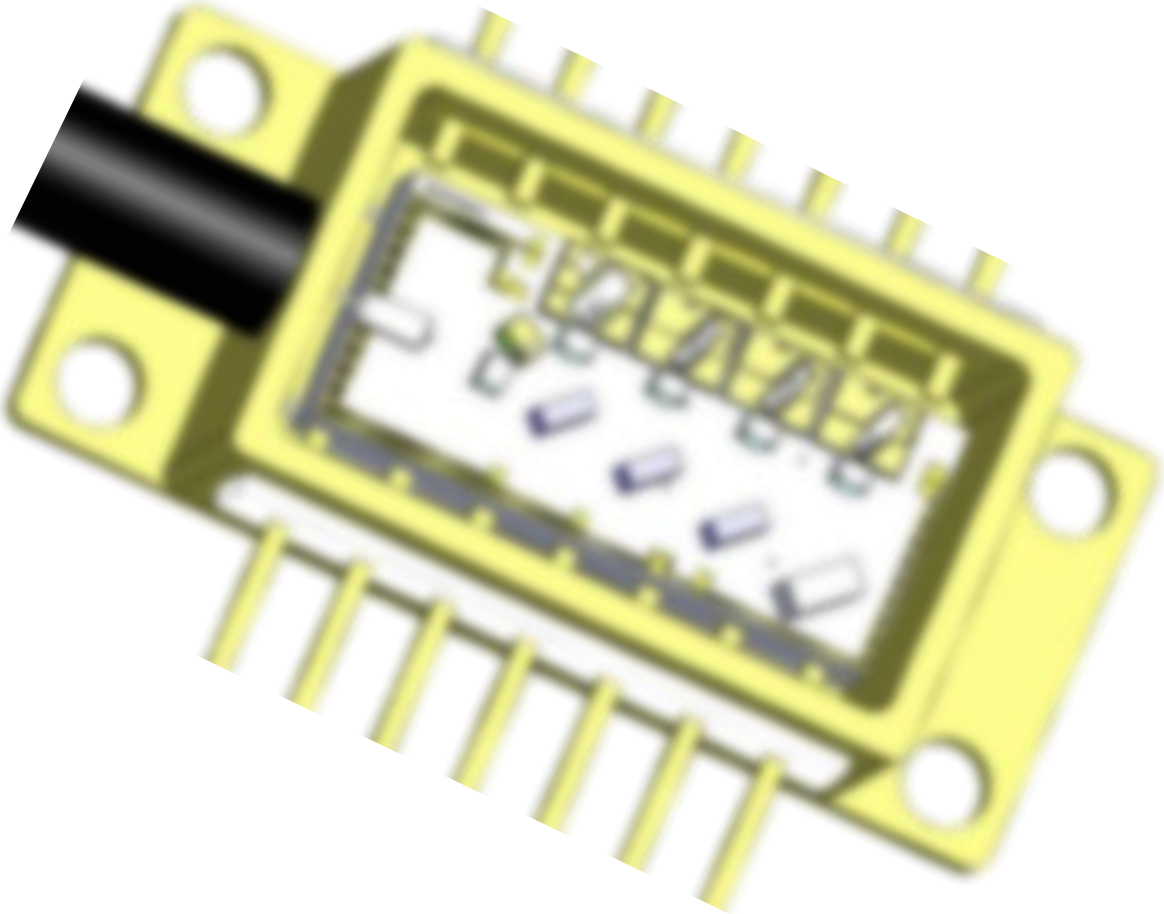
# MICRO-OPTICAL ASSEMBLY (AUTOMATED)



- The micro-optical passive components (e.g., lenses, filters, beam splitters, etc.) are precisely positioned with automated pick & place processes
- Certain components are positioned using automated active alignment
- The bonding is based on UV-curable epoxies with low outgasing
- The machines perform automated glue dispensing & automated UV curing & automated baking

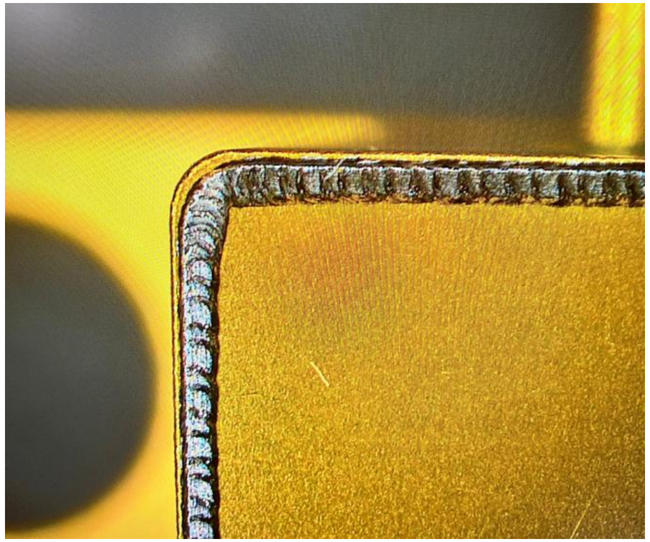
# FINAL INSPECTION (AUTOMATED)

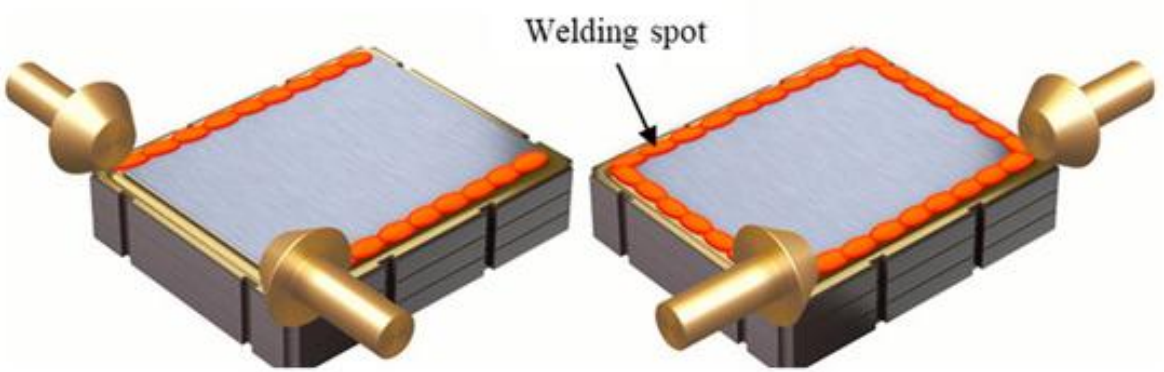
- Fully assembled modules go through an automated visual inspection with high-precision automated position measurements of components (quality control)



# HERMETIC SEALING (SEMI-AUTOMATED)

https://pwsystems.co.uk/seam-sealing-electronic-packages/



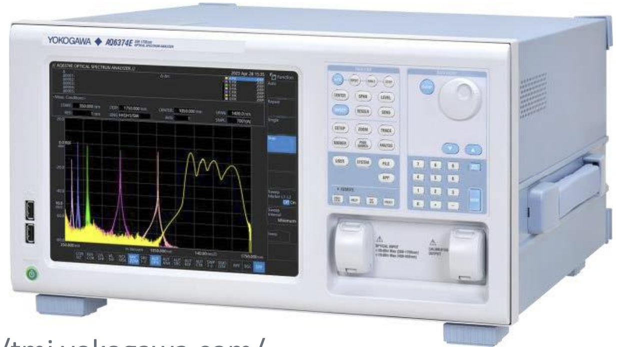


https://www.mdpi.com/2227-9717/12/1/78

- Completed modules are hermetically sealed using seam welding
- Batch process, i.e., multiple Butterfly modules are loaded into a chamber with a controlled gas atmosphere
  → baking for a period of time
  → sealing of lid to the housing
- The sealing itself is automated, but many manual steps are required …

# FINAL TESTING (AUTOMATED)

https://www.newport.com/c/light-analysis



https://tmi.yokogawa.com/

- Each module undergoes full electro-optical testing for compliance to specification
  → certificate of conformance
- Module testing (and possibly module-level burn-in) can consume a lot of time and resources …
- Automated test stations with automated fiber switches reduce operator time and handling, but requires manual module loading and manual fiber connection

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# PROCESS SUMMARY

Current Manufacturing Steps:

- Butterfly pre-assembly (manual)
- TEC wire assembly (manual)
- Chip-on-submount placement (automated)
- Wire bonding (automated)
- Fiber feedthrough (manual)
- Hermeticity plug soldering (manual)
- Micro-optical assembly (automated)
- Final inspection (automated)
- Hermetic sealing (semi-automated)
- Final testing (automated)

- Manufacturing fiberized Butterfly modules still requires a lot of manual steps !
- Building optical modules entirely in a fully automated way is probably possible, theoretically, but maybe not realistic – unless it's a high-volume product with millions of units per year

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Current Manufacturing Steps:

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- Hermetic sealing (semi-automated)
- Final testing (automated)

- Hermetic sealing of optical (Butterfly) modules is currently not done in-house at EXALOS/indie but subcontracted to an external partner
- Having sealing capabilities within Switzerland (with the right sealing gas atmosphere) would be interesting for us !

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