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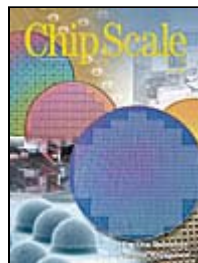
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### March 2003



The International Reference for Chip-Scale Electronics, Flip-Chip Technology, Optoelectronic Interconnection and Wafer-Level Packaging

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## Optoelectronics Packaging - Building upon Integrated Circuit Manufacturing Expertise



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### Fiber Alignment and Attach

The final assembly step of a laser diode is the alignment and attach of an optical fiber. The intrinsic variability of both the diode optical output and the optical center of the fiber require the fiber to be actively aligned.

During active alignment, the position of the fiber relative to the diode is adjusted as a function of the output power (positioned for maximum throughput power).

To optimize coupling efficiency of single-mode devices, the final alignment must be made to within 0.1  $\mu\text{m}$  of the actual peak, post-attach. Attach methodologies include laser weld, solder or epoxy. Depending on the specific device and attach process, a post-attach correction may be required to maximize the power output of the device.

### Metrology

One common set of measurements that can be used to gain insight into the chip attach integrity is an LIV (light, current, voltage) test. In this measurement, the drive current through the laser is ramped from zero

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to the laser's maximum operating current and the output power of the laser and the forward voltage across the diode junction are recorded.

LIV tests are common in the semiconductor laser industry, but it is the comparison between CW (continuous wave) and pulsed current LIV curves that can give an indication of chip attach integrity.

If the heat flow through the die bond is high, the two curves will be similar. If there is a flaw in the bond, the heat flow will be low, the laser chip will heat during CW operation and the two curves will be substantially different.

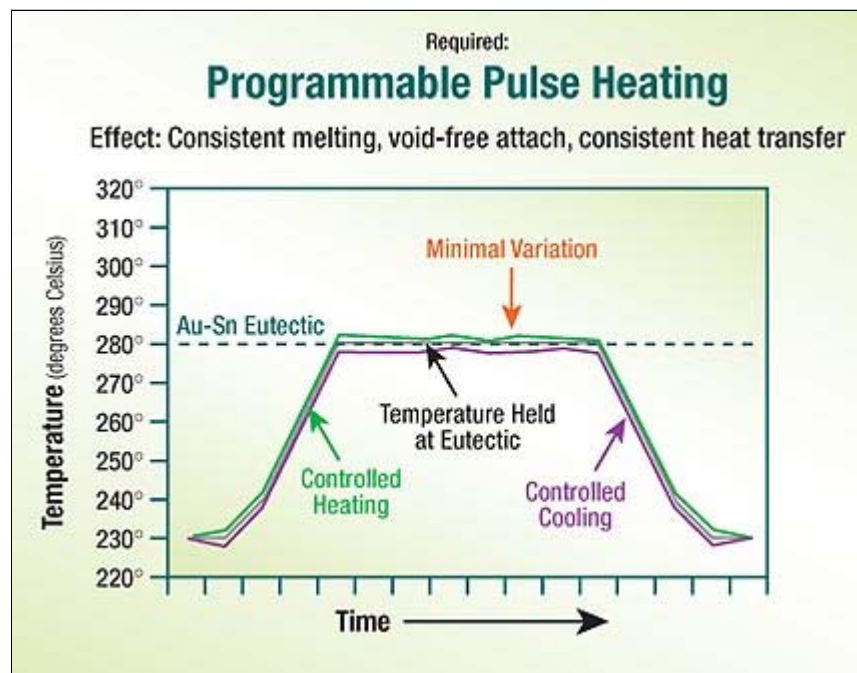


Figure 4. Programmable pulse heating

However, in the method stated above, the conclusion is of a pass/fail nature. The chip attach process is either good enough, or the test indicates failure. A quantitative measure of die bond efficacy can be obtained by making use of the fact that several measurable characteristics of laser diodes depend on junction temperature.

Output power, forward voltage, wavelength and threshold current all depend on junction temperature. The most straightforward method involves measuring the wavelength of the laser, and allows a calculation of the thermal impedance ( $R_{th}$ ), which is a direct measure of chip attach quality.

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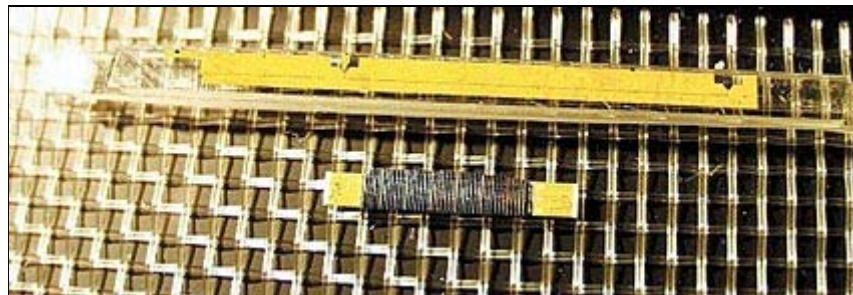


Figure 5. A single LiNbO<sub>3</sub> modulator next to a chip that contains dozens of InP modulators. The modulators on the InP chip run top to bottom and the vertical lines are the individual modulators.

### Putting It All Together

The packaging process for an optoelectronic device challenges efforts to reduce costs. Because the purpose of an optical component is to manipulate light, the design rules for packaging are significantly more complex than those found in the semiconductor industry.

With semiconductors, advances in wafer processing drive technology, and packaging is very automated and planar. With optical components, the front-end process is significant as we have seen, but equally important for photonic devices are package design, controlled assembly processes and meeting critical assembly alignment and positioning tolerances.

Currently, the optoelectronic component manufacturing industry is under considerable downward cost pressure. Most manufacturers have recognized that a paradigm shift in assembly methods will have to take place for them to drive down component costs and accelerate time-to-volume. That shift is emerging as a move from the manual assembly processes that have characterized the industry for decades to high-accuracy, high-yield automated manufacture and test.

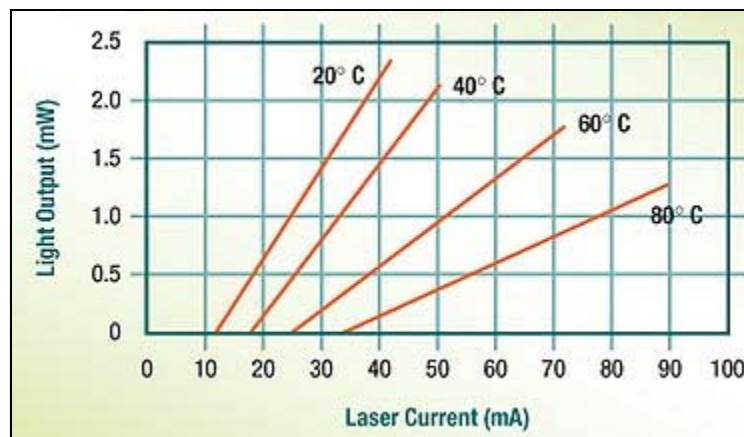


Figure 6. Continuous wave L/I curve

While automation will eventually be able to provide complete process solutions for the optical component assembly industry, currently there are significant challenges to automation.

The combination of extreme accuracy and process requirements, significant variations in fiber-to-package I/O heights, unusual form factors, unusual materials and the inherent difficulties arising from the requirement to guide light have prevented most equipment available today from being utilized in optical component packaging.

Fortunately, some systems have the flexibility to support these difficult tolerances and process requirements. Specifically, die attachment and wire bonding techniques that were developed in the hybrid semiconductor and high-frequency wireless industries are currently being incorporated into the optical component manufacturing industry.

### Conclusion

We are seeing the emergence of an equipment supplier base able to support the stringent tolerances of the optoelectronic component assembly industry.

The equipment that these suppliers are designing today will not only facilitate the efficient manufacture of optical components, but will enable the component designers to continue to push the envelope of communications technology into the foreseeable future.

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