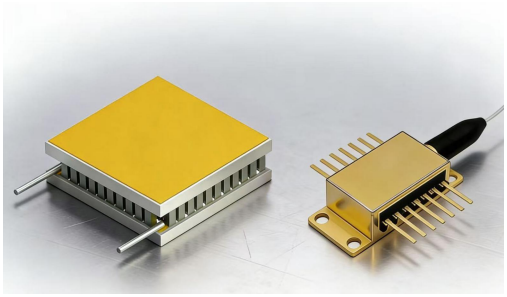
Technical Summary

TEC Cooling for Butterfly Lasers

Overview

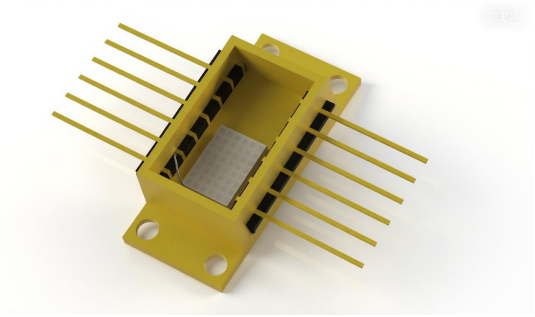


In both high-speed optical communication and precision medical imaging, laser performance requirements have reached the physical limits: absolute wavelength stability, ultra-low noise, and rapid response. The butterfly package, with its excellent heat dissipation, low-inductance RF interface, and compact integrated fiber output, provides an ideal platform for high-performance laser chips.

The embedded thermoelectric cooler (TEC) is the key element that gives this platform its precision "soul"—through solid-state, highly accurate temperature control, the TEC locks the laser's performance at the set point, overcoming environmental and self-induced thermal fluctuations.

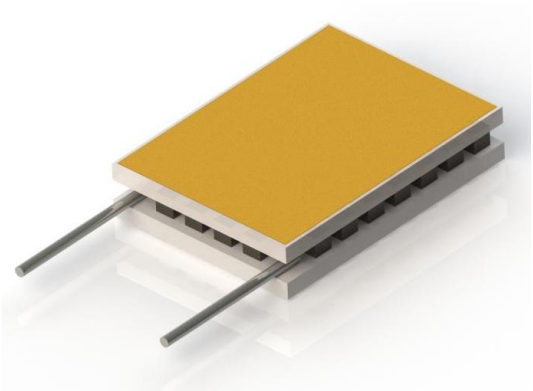
Butterfly Laser Device-Level Performance Improvements

The butterfly-packaged TEC provides precise enhancement of core laser performance:



- **Absolute wavelength stability**: Maintains operating temperature within ±0.01°C, achieving wavelength stability on the ±0.001 nm level, meeting the most stringent DWDM system requirements.
- **Power and efficiency stability**: Constant temperature ensures stable threshold current and slope efficiency, guaranteeing consistent output power and optimal electro-optical conversion efficiency.
- **Extended lifetime and reliability**: According to the Arrhenius model, actively controlling the chip junction temperature at a lower level (e.g., from 85°C down to 45°C) can extend laser lifetime by an order of magnitude (10× or more).
- **Reduced system bit error rate (BER)**: From 10^{-6} to 10^{-12}.
- **Uninterrupted network operation**: Complies with telecom-grade equipment lifetime requirements of 25 years.
- **Device miniaturization and high-density integration**: Butterfly packaging is the core for coherent technology in high-speed optical modules such as CFP2 and QSFP-DD.

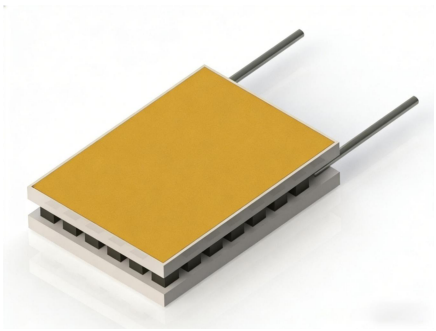
System-Level Impact



TEC cooling stabilizes the butterfly laser operating point, delivering key system benefits:

- **Enhanced signal stability**: Long-term stability of wavelength, power, and modulation performance.
- **Reduced system BER and packet loss**: Ensures reliable operation of high-speed optical networks.
- **Extended module lifetime and reduced maintenance cost**: Controlled chip junction temperature significantly prolongs operational lifetime.
- **Support for high-density integration and miniaturization**: Meets compact design requirements of modern optical modules.

Representative TEC Models for Butterfly Laser



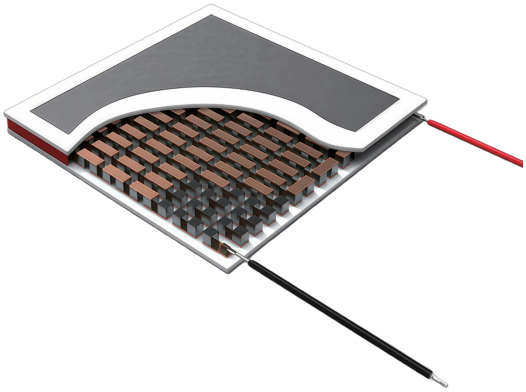
The following models represent typical TEC platforms commonly used in butterfly laser packages. They are provided for reference only and do not represent a complete product list.

Model	TEC Stages	Typical ΔT	Typical Cold-Side Temperature	Typical Applications
TEC-1	Single-stage	~30 K	Room temp to 15°C	DFB lasers
TEC-2	Multi-stage	~50 K	Room temp to 10°C	EML / high-power lasers
TEC-Custom	Custom	According to requirement	According to requirement	Special package or thermal constraints

Electrical, mechanical, and thermal parameters can be customized based on specific device and system requirements.

TEC Advantages for Butterfly Lasers Applications

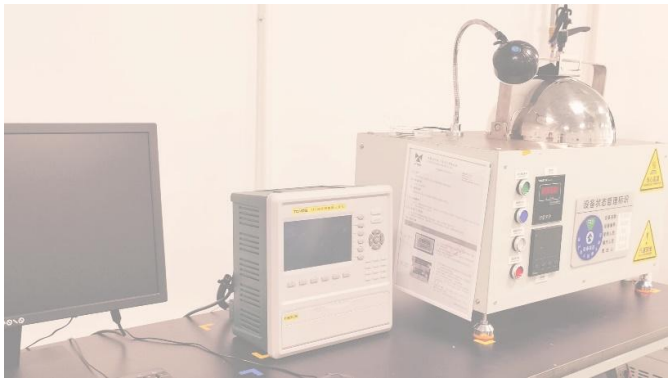
- Solid-state design with **no moving parts**
- **Zero vibration**, ensuring imaging stability
- Precise temperature control (±0.1 K typical)
- Compact, lightweight, and orientation-independent
- Refrigerant-free with low electromagnetic interference (EMI)
- Suitable for harsh and wide ambient temperature environments



Test & Qualification Capability

Performance validation and reliability testing are conducted in dedicated laboratories, including:

- Environmental and thermal cycling tests
- Long-term stability and life testing
- Qualification aligned with **MIL-STD-883** and relevant industry standards



Test scope and qualification standards may vary depending on application requirements.

ABOUT P&N TECHNOLOGY,P&N EUROPE & i-TEC

P&N China and **i-TEC** provide thermoelectric cooling solutions for **high-end scientific and industrial applications.** P&N China focuses on large-area and system-level thermoelectric solutions, while i-TEC specializes in compact and multistage thermoelectric solutions for precision temperature control.

P&N Europe (est. 2018) supports European customers through technical sales and regional logistics coordination.

With over **20 years of experience** in thermoelectric technology, **we emphasize quality, reliability, and long-term performance** in our thermal management solutions and products.

Engineering Support & Contact

Our application engineering team provides support for:

- TEC selection and thermal modeling
- Module-level and System-level Integration
- Performance validation and reliability considerations

Contact us to discuss your thermal management requirements.
Technical consultation and sample evaluation are available.

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