Laser-Based Floating Zone Furnace

Quantum Design is proud to introduce a laser-based floating zone (L-FZ) furnace. This novel system, based on technology developed by RIKEN CEMS (Center for Emergent Matter Science) in Japan, promises the opportunity to grow materials unable to be grown by more traditional floating zone methods.

This 1.5KW or 2KW high-power furnace allows growth of:

- Materials that melt within a narrow temperature range
- Materials with incongruent melting (ideal solution for TSFZ process)
- Materials with high vapor pressures near the melting temperature
- Metallic compounds with large thermal conductivity coefficients

Single crystals of high refractory materials (T_m > 2000 °C) are easily grown:

Ruby (T_m ~2072 °C)

Ruby with such a clean crystal surface cannot be grown in a Ha-FZ furnace.

Y-type Ferrite; $Ba_2Co_2Fe_{12}O_{22}$ (Tm 1440 °C) *(room temperature multi-ferroic materials)*

Single crystals of materials with incongruent properties at melting temp. due to a narrow melting temperature range (10 °C) cannot easily be grown by Ha-FZ method.

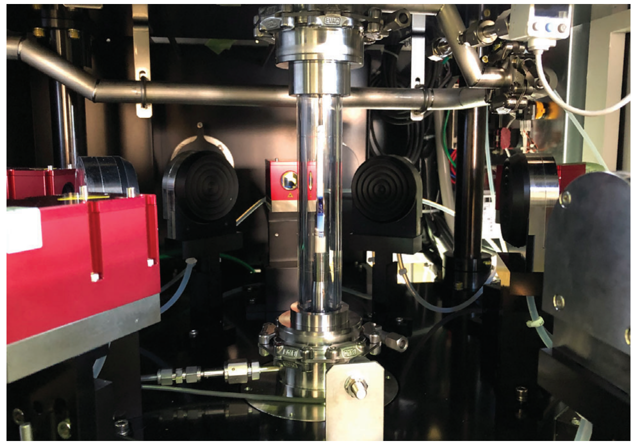
SmB_6 (T_m ~2345 °C) *(a topological insulator)*

Materials with refractory and high conductivity properties cannot be grown in a Ha-FZ furnace.

Patented technology:

The laser-based FZ furnace consists of a 5 laser-head design for guaranteed high uniformity of power density in the FZ region. The laser profile has been optimized to reduce thermal stresses during the crystal growth process. In addition, the system includes an integrated temperature sensor for real-time temperature readout and control.

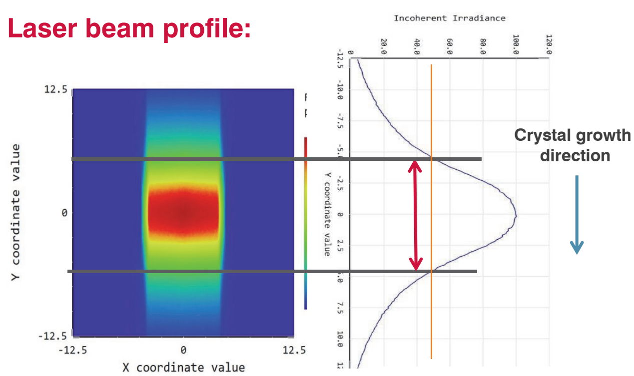
* *Photographs of the single crystals and data provided by Dr. Y. Kaneko of RIKEN CEMS.*



Wide temperature range from low to high melting temperatures available:

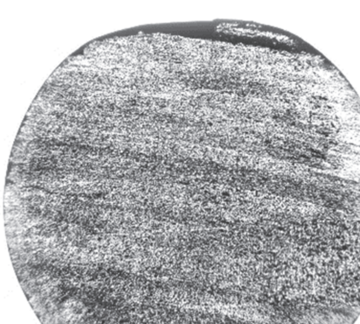
- One unit can cover the entire temperature range that traditionally requires both Halogen and Xenon lamps to achieve. **400 to 3000 °C** is achieved in one platform.
- No laser alignment or other adjustments to the optical system are necessary to cover the entire range of laser power.

Laser beam profile:



- The irradiation intensity distribution of the heating laser is **circumferentially uniform**. Whereas in thedirection of the crystal growth, a **gradual irradiation intensity** distribution is adopted.
- A circumferential homogeneity of **over 95%** of irradiation intensity on the outer surface of the raw material is achieved
- This optimization of the laser beam profile reduces thermal stresses on crystals as compared against conventional laser FZ consisting of a more traditional top-hat laser power profile.

$TbMnO_3$ grown in the L-FZ system with a more **gradual** laser power profile illustrated above – note the absence of cracks!

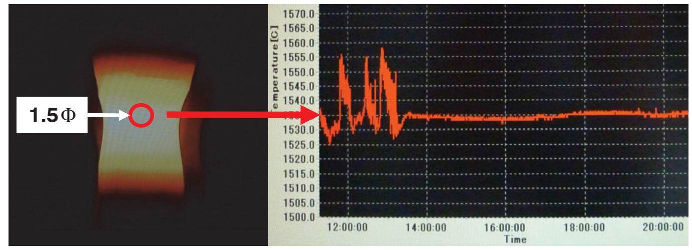


The temperature can be monitored and controlled with precision and in real time:

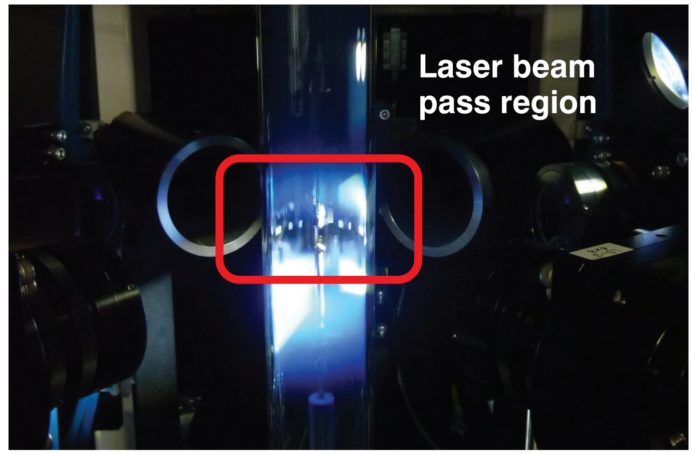
- Temperature monitored with spatial resolution of **better than φ1.5 mm.**
- Temperature of molten zone can be directly monitored and recorded over the entire temperature range **up to 3000 °C** with an integrated radiation thermometer.
- High precision single crystal growth: High precision temperature control of the desired melting zone temperature is possible.
- The temperature of the melting zone can be controlled to the target temperature on the phase diagram with minimal temperature overshooting, ensuring growth of the desired compound. Conventionally, there has been no choice but to judge by observing the fluctuating state of the molten zone.
- Ideal for crystal production by the TSFZ method requiring long-term, unattended temperature control over a narrow temperature range.
- Reproducibility of measured temperature is **within ± 1 °C**. Once the optimum temperature is found, the laser power can be controlled to the optimum temperature with excellent reproducibility.

Ideal for materials with high volatility:

- Since the irradiation spot is small, contamination of the inner surface of the quartz tube is small, and single crystal growth is possible even for highly evaporative materials.
- It is possible to install a quartz-tube protection sleeve for the evaporative materials, simplifying the cleaning of the quartz tube after use. Only cleaning of this protective sleeve is necessary.



Temperature monitored with pinpoint accuracy of **better than 1.5ϕ**



The floating zone furnace could be used with both, oxygen-gas mixtures as well as oxygen-free Argon gas mixtures for alloy single crystal growth.

Specifications*

* Subject to change without notification

Heating control	Number of laser beams/heads	5 laser beams from 5 laser heads, high power diode laser
	Laser total power in FZ region	1500 watts (300 watts ×5 beams) or 2000 watts (400 watts ×5 beams)
	Temperature range	400 °C ~ 2750 °C (based on melting of HfO_2)
	Temperature monitoring	800 °C ~ 3000 °C (radiation thermometer)
	Temperature reproducibility	±1 °C over entire temperature range
	Temperature FB control	±0.5 °C over entire thermometer temperature range
Crystal Growth Control	Crystal growth max. length	150 mm
	Crystal diameter	> 8.0 mm (material dependent)
	Growth speed, Rotation speed	0.1 to 300 mm (mm/hr) / 0.1 to 40 rpm
	FZ region vacuum / pressure	0.01 Pa / 1 MPa
	FZ Environment	User-supplied external gas
	Growth monitoring	High vision full HDTV camera
Others	Instrument footprint	W 250 x D 200 x H 220 (cm) (approximate)

Distributed by:

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