Quantum Design JAPAN

"Laser-Based Floating Zone Furnace"

Developed in collaboration with the RIKEN institute in Japan

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

This high-power laser furnace (1.5 or 2KW models available) allows growth of the following:

- 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.

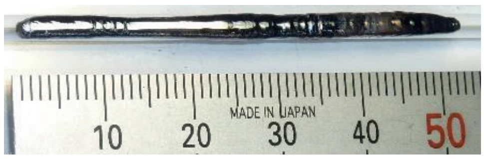
Patented technology:

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.

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 can not be grown in a Ha-FZ furnace.



SmB_6 (T_m ~2345 C) (A topological insulator)

Materials with refractory and high conductivity properties can not 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 (10C), this material can not be easily grown by Ha-FZ method.

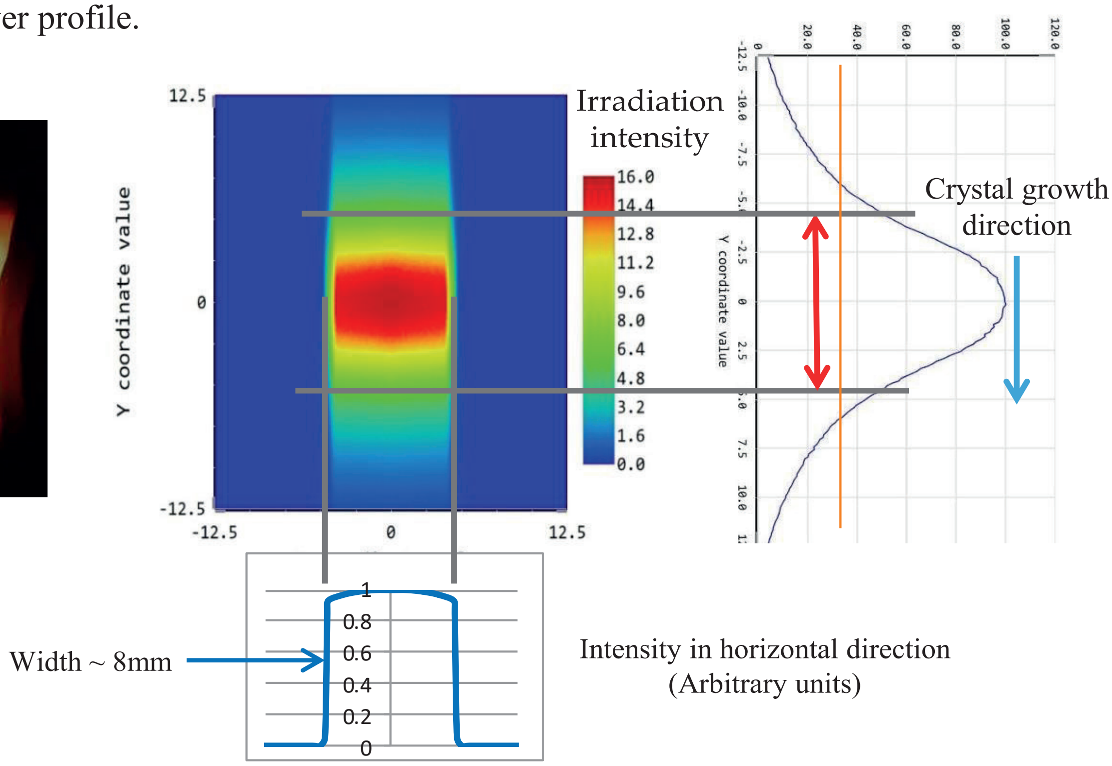
* Photographs of the single crystals and data provided by Dr. Y. Kaneko of RIKEN CEMS.

1. *Available wide temperature range from low to high melting temperatures:*

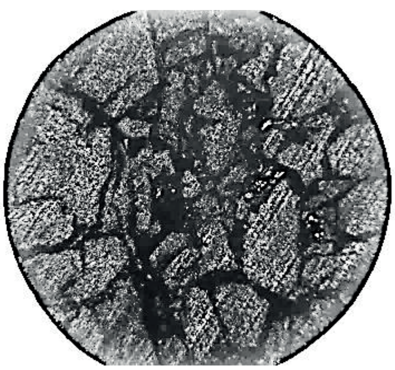
- One unit can cover the entire temperature range that traditionally requires both Halogen and Xenon lamps to achieve. ***400 to 3000 C*** is achieved in one platform.
- No laser alignment or other adjustments to the optical system are necessary to cover the entire range of laser power and floating zone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

2. *Laser beam profile optimization:*

- The irradiation intensity distribution of the laser is ***circumferentially uniform***.
- A more ***gradual irradiation intensity*** distribution is adopted in the direction of crystal growth to help minimize thermal stresses within the material.
- A circumferential homogeneity of ***over 95%*** of irradiation intensity on the outer surface of the raw material is achieved (excellent circumferential uniformity as compared to a Ha-FZ platform).
- This optimization of the laser beam profile reduces thermal stresses on crystals as compared against a conventional laser FZ furnace consisting of a traditional top-hat laser power profile.

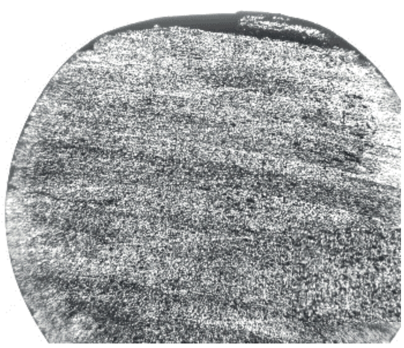


TbMnO$_3$ grown in a L-FZ furnace with a typical ***top-hat*** laser power profile - cracks in the material due to thermal stresses.



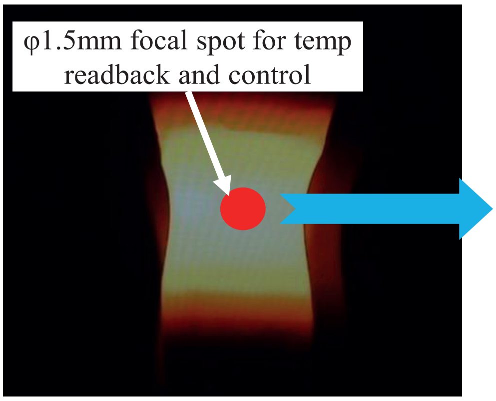
TbMnO$_3$

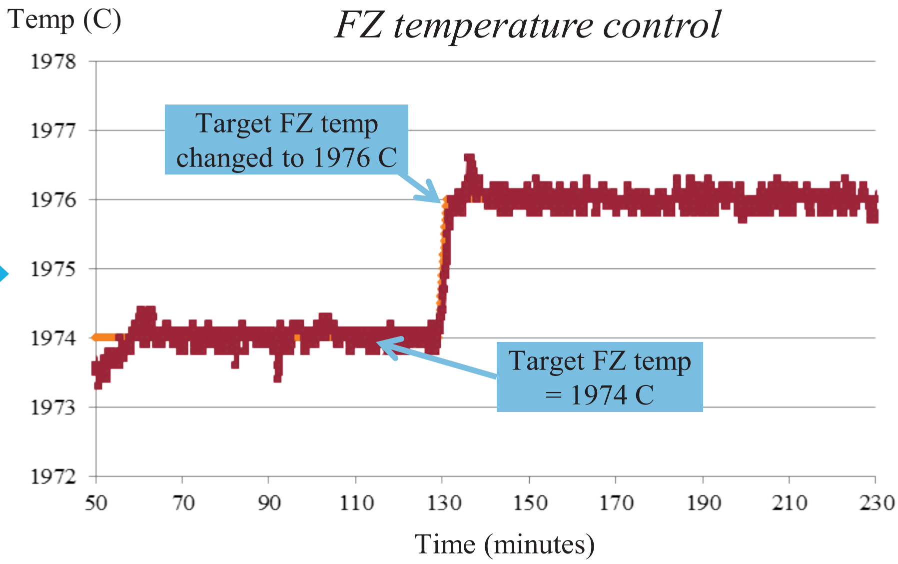
TbMnO$_3$ grown in the L-FZ furnace with a ***gradual*** laser power profile shown above - few cracks in the material.



3. ***The temperature can be precisely monitored and controlled in real time:***

- Temperature monitored with spatial resolution of ***better than φ1.5mm***.
- Temperature of molten zone can be directly monitored and recorded over the entire thermometer temperature range from ***800 up to 3000 °C*** via a customized radiation thermometer.
- Precision temperature control of the desired melting zone temperature throughout the crystal growth process is now 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. In a conventional Ha-FZ furnace, control of the FZ molten region is typically visual.
- Ideal for crystal production by the TSFZ method requiring long-term, unattended temperature control over a narrow ***1°C*** temperature window.
- Reproducibility of measured temperature is ***within +/-1°C***.

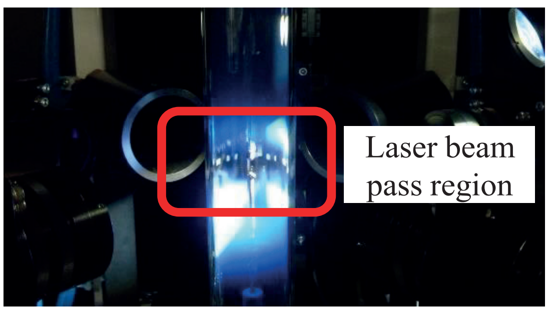




4. ***Ideal for materials with high volatility:***

- Compared to a traditional Halogen or Xenon lamp, the laser generates a much more concentrated energy profile at the FZ region.
- Less of the feed material is exposed to the higher temperatures generated by the energy source, lessening the amount of evaporative material which can contaminate the quartz tube.
- The focused laser power acts to ablate any evaporates that may contaminate the quartz tube, leaving the quartz tube relatively clean in the laser-beam pass region.
- Optional thin-wall protective quartz sleeves are available to help further protect the inside diameter of the quartz tube from damage or contamination.

Sr_2RuO_4 (T_m ~ 1860 C)



Optional accessories:

•**High vacuum pumping system:** For pumping the floating zone region down to less than 0.001 Pa.

•**Cold trap:** For trapping materials that outgas from the feed rod.

•**Gas curtain:** Generates a gas sheath flow along the inner wall of the quartz tube which helps reduce contamination of the quartz tube.

•**Mass flow controller:** Provides fine PC controlled gas flow to the floating zone region. Up to two gases may be mixed.

•**Bake-out system:** Heater that is applied to the quartz and metal tubes. During the evacuation of the floating zone region, this heater can be used to help remove any contaminates for a more thorough initial evacuation of the FZ region.

•**Transfer rod:** A magnetically-coupled shaft drive system that eliminates any o-ring seals. This helps limit risk of contamination to the floating zone region.

•**Quartz sleeves:** Thin-walled quartz sleeves that fit within the main floating zone quartz tube. These tubes help prevent the main quartz tube from contamination and damage.

Specifications*

* Subject to change without notification

Heating control	Number of laser beams / heads	5 laser beams from 5 laser heads, high powered diode laser
	Laser total power in FZ region	1500 watts (300 watts × 5 beams) or 2000 watts (400 watts × 5 beams)
	FZ temperature range	400 ~ 2750C (based on melting of HfO_2)
	Temperature monitoring	800 ~ 3000C (via radiation thermometer)
	Temperature reproducibility	+/-1C over entire temperature range
	Temperature FB control	+/- 0.5C 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	W250x D200 x H220 (cm) (approximate)

Quantum Design
1 avenue de l'Atlantique
Bâtiment Fuji-Yama
91940 Les Ulis - France

Tél. : +33 1 69 19 49 49
france@qd-europe.com
www.qd-europe.com