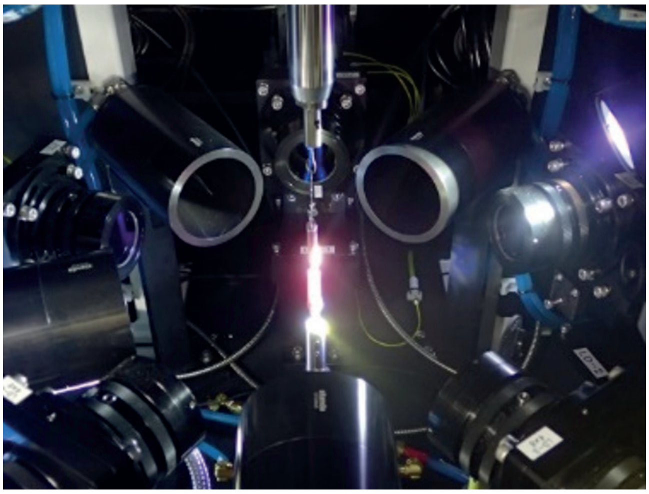
Laser-based floating zone furnace

Quantum Design is proud to introduce a laser-based floating zone (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 traditional floating zone methods.



This 2 KW-class furnace allows growth of

- Materials that melt within a narrow temperature range.
- Materials with incongruent melting (ideal solution for traveling solvent floating zone process).
- Materials with high vapor pressures near its melting temperature.
- Metallic compounds with large thermal conductivity coefficients.

Available wide temperature range from low to high melting temperatures

- One unit can cover the entire temperature range.
- No laser alignment or other adjustments to the optical system are necessary to cover the entire range of laser power.

Easily grown crystals

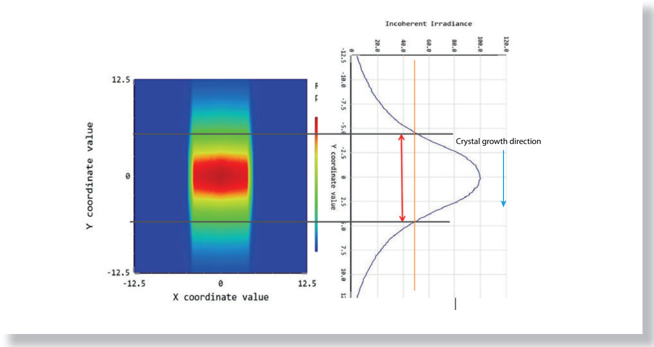
A Ruby single crystal (T_m ~2072 °C) with a high refractory clean crystal surface.

A Y-type Ferrite;
$Ba_2Co_2Fe_{12}O_{22}$ (T_m 1440 °C), a room temperature multi-ferroic material, is grown to a single crystal with incongruent properties at melting temperature; due to a narrow melting temperature range (10 °C).

SmB_6 (Tm ~2345 °C). A topological insulator with refractory and high conductivity properties.

A traveling solvent FZ $SrCu_2(BO_3)_2$ crystal could be grown over 320 hrs (14 days), growth speed 0,25 mm/hr). With the FZ system, automated feedback control of the environment is possible to precisely monitor and control the temperature, greatly reducing the required labor.

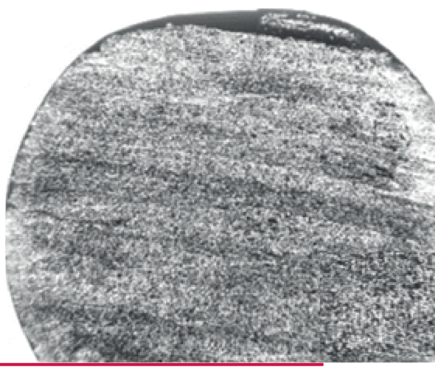
Laser beam profile



- The irradiation intensity distribution of the heating laser is **circumferentially uniform**. Whereas in the direction 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 with conventional laser FZ consisting of a more traditional top-hat laser power profile.

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.



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

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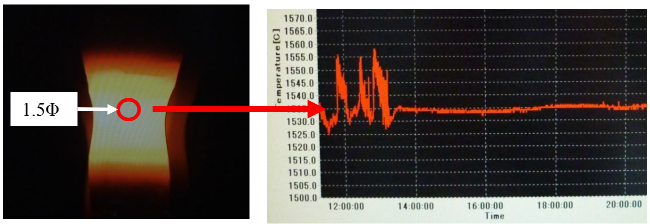
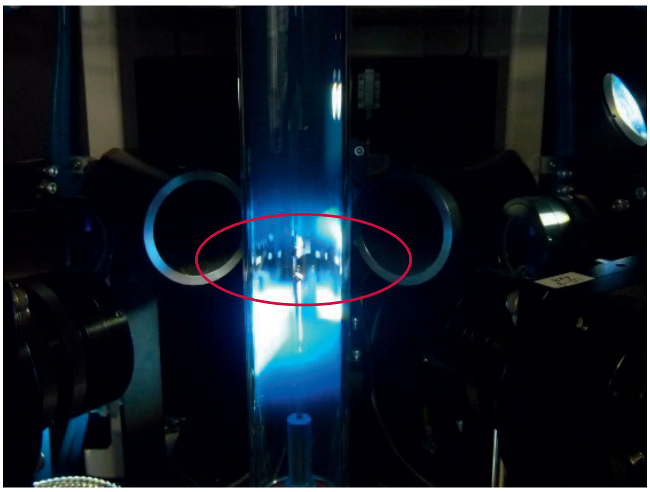


The temperature can be monitored and controlled with precision and in real time

- 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 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 traveling solvent FZ 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 work after use.



Laser beam pass region

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		
Heating control	Number of laser heads / beams	5 laser beams
	Laser power in FZ region	2000 watts (400 watts × 5 beams)
	Temperature range	400 °C ~ 3000 °C (material dependent)
	Temperature monitoring	400 °C ~ 3500 °C (radiation thermometer)
	Temperature reproducibility	±1 °C over entire temperature range
Crystal growth control	Crystal growth max. length	150 mm
	Control	8 mm
	Growth/rotation speed	0.1 to 200 mm (mm/hr), 0.1 to 40 rpm
	Pressure range	$1 * 10^{-4}$ torr to 10 bar
	Environment	User-supplied external gas
	Growth monitoring	High vision full HDTV camera
	Operation control	Ubiquitous control possible by PC/ Smartphone from your desk/home for remote monitoring/control of the crystal growth process
	Dimension	D 140 x W 210 x H 200 [cm]

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