

“GAS GUIDE”

in the Optical Floating Zone Furnace

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Introduction

The Optical floating zone furnace has been accepted as the most useful and powerful tool for the growth of single crystals and had been successfully applied for the growth of various materials including oxide, metal and inter-metallic compounds. The optical floating zone method had many advantages, however, this method needed to use the transparent quartz tube, therefore, keeping the transparency of the quartz tube was the key element to use the optical floating zone furnace in a best condition. Crystal Systems Corporation had developed a new technique called “Gas Guide” to meet this requirement.

2. Differences among the three types of the focusing system

Single, double and four mirror focusing system had been developed and used for the optical floating zone furnaces. There were some important differences between these systems. The effective length of the quartz tube was one of them.

Both the single and double mirror system, for example, the part of the quartz tube, which was placed to the inside of the ellipsoidal mirror, became an effective zone. Therefore, this zone needed to be kept in a clean condition. The length of this effective zone of the four mirror system was shorter than that of both the single and double mirror system (**Fig.1**).

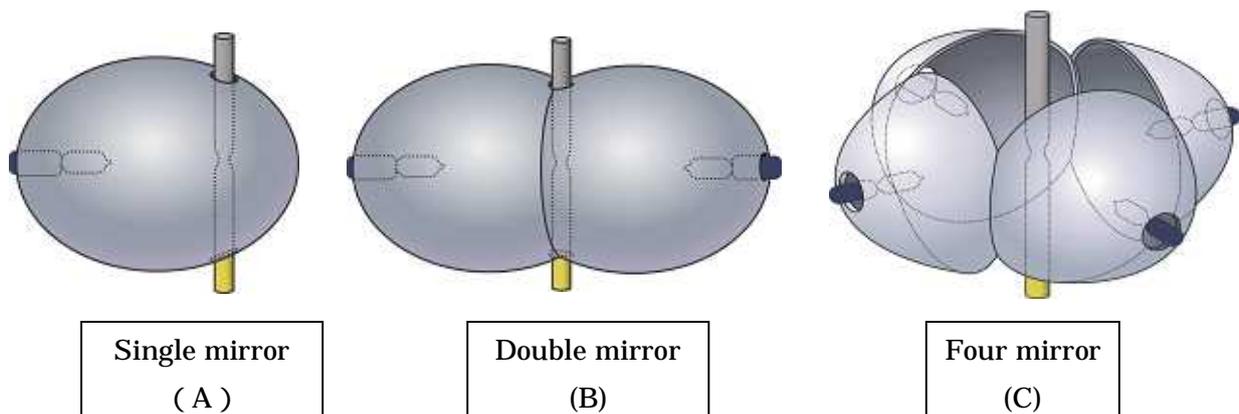


Fig.1 Three types of the focusing system for the optical floating zone furnace.

In the case of the four mirror system, the center portion of the mirror system has wide space and both the single and the double mirror system has no such space between the quartz tube and the mirrors.

This meant that the four mirror system could prevent the deposition of small particles from the surface of the quartz tube (Fig. 2).

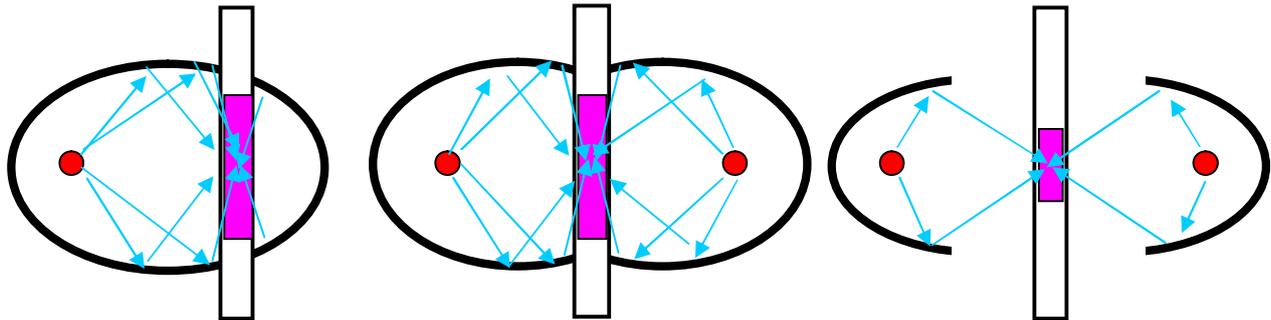


Fig.2 The Effective zone for the focusing of the infra red rays in the corresponding different mirror systems. The length of this zone in the four mirror furnace is much shorter than that of both the single and the double mirror system.

3. Traditional techniques for keeping the quartz tube clean

3.1 Use the large flow of the atmospheric gas

In some cases, the evaporation from the melt occurred during the growth, and many small particles were condensed to the surface of the quartz tube. In these cases, a large flow of the atmospheric gas; more than 20cm per second inside the quartz tube, would be taken out from the quartz tube chamber, so the surface of the quartz tube was kept in a clean condition. This technique seemed to be simple, easy and no problems. However, in the case of pure argon gas, which was needed as the atmosphere, the cost became high and conducting a long-time experiment became difficult.

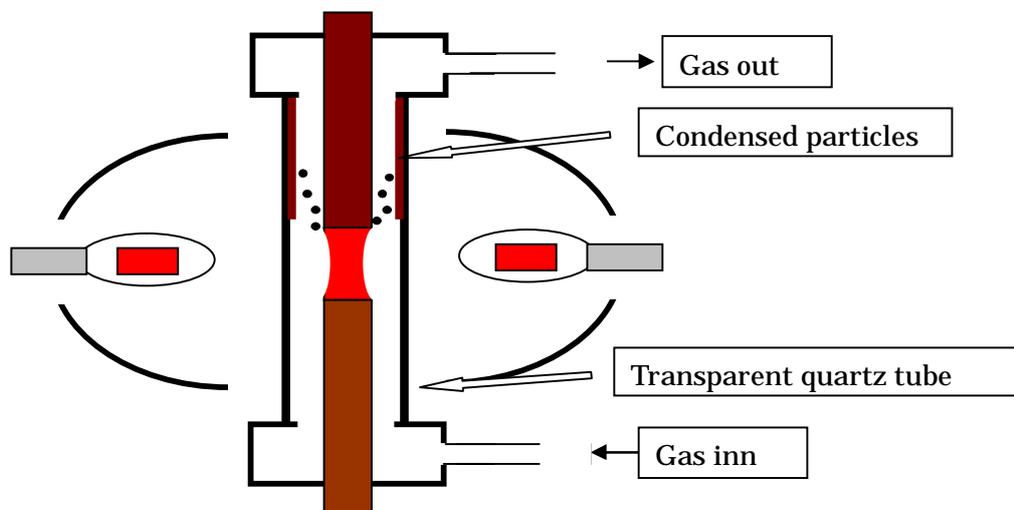


Fig.3 . Schematic illustration of the optical floating zone furnace.

Small particles of the evaporated materials from the molten zone would condense and deposit on the surface of the quartz tube, then transparency become poor gradually and in some cases, the condensed materials would react the quartz and the life time of the quartz tube become very shortened.

Maeno et al developed the new technique for the use of the cold trap introduced into the quartz tube (See Japan Tokkyo Kokai 2005-247668). The schematic diagram of this technique was seen in **Fig. 4**.

Small particles were more condensed on this cold metal trap than the surface of the quartz tube, but this metal trap shielded the infra red rays, therefore, the position of it influenced the temperature of the molten zone. The effect of this trap became larger according to the close setting to the molten zone, while the temperature of the molten zone became lower.

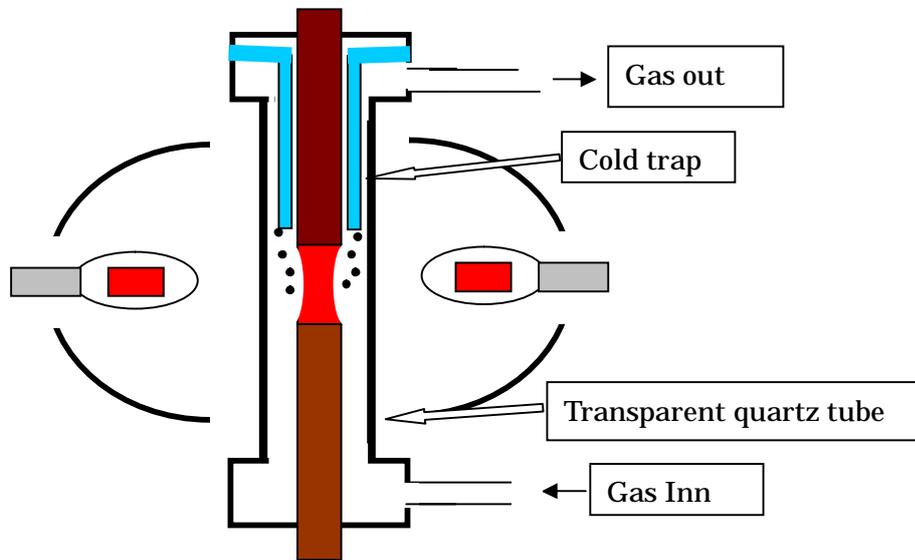


Fig.4 Schematic diagram of the cold trap inserted in the quartz tube and focusing scheme. Small particles from the molten zone would be condensed on the cold trap rather than the surface of the quartz tube, then can keep its clean condition more long time compared to the normal case without the cold trap.

4. The use of the gas guide

In the four mirror focusing system, a large flow of the atmospheric gas (more than 20cm per second) can take out almost all of small particles from the molten zone to the outside of the quartz tube, so that the surface of the quartz tube in the four mirror focusing system can be kept in a clean condition even under the long-time experiment of the growth of evaporated materials. This means that the smaller cross sectional area in the quartz tube would be more sufficient to keep the inside of the quartz tube in a clean condition even under the use of the same amount of the atmospheric gas. In normally, the 20mm diameter shaft is used for the floating zone furnace, then the flow rate on the 2 liter per minutes inside the 24mm inside diameter quartz tube become more than 20cm/sec. As a good example, the surface of the quartz tube could keep the clean condition more than 24 hours in the case of the growth of YVO₄ under the same atmospheric condition.

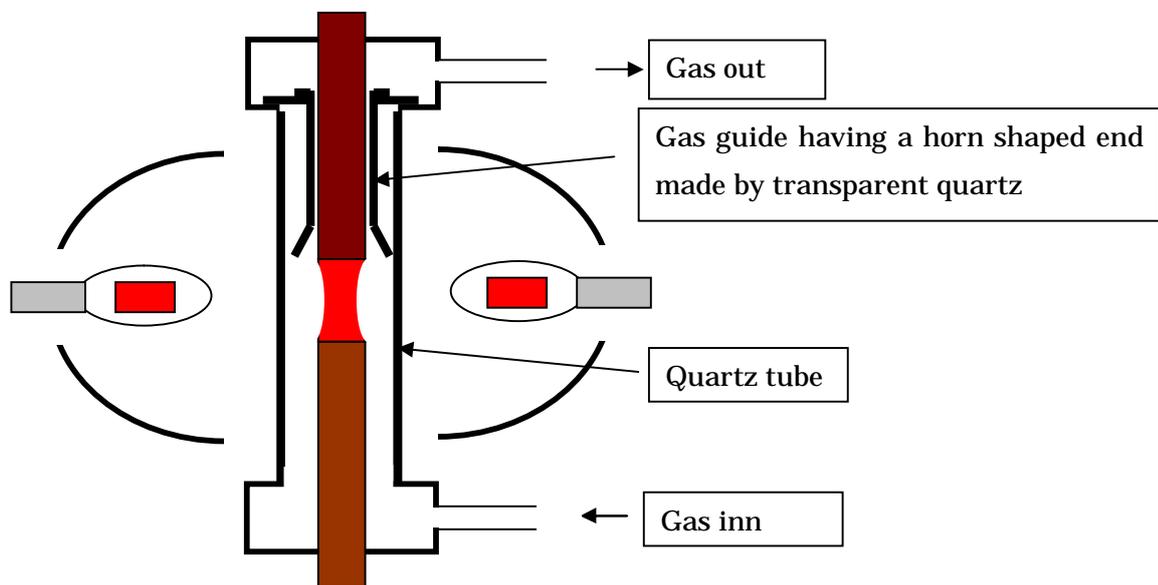


Fig.5 Schematic diagram of the gas guide having a horn shaped end inserted into the quartz tube.

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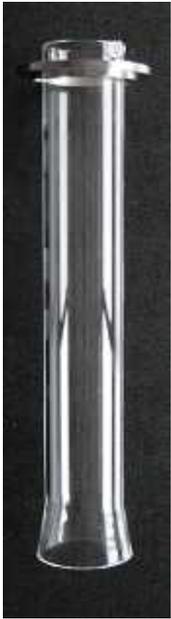


Fig.6 Photo of the gas guide

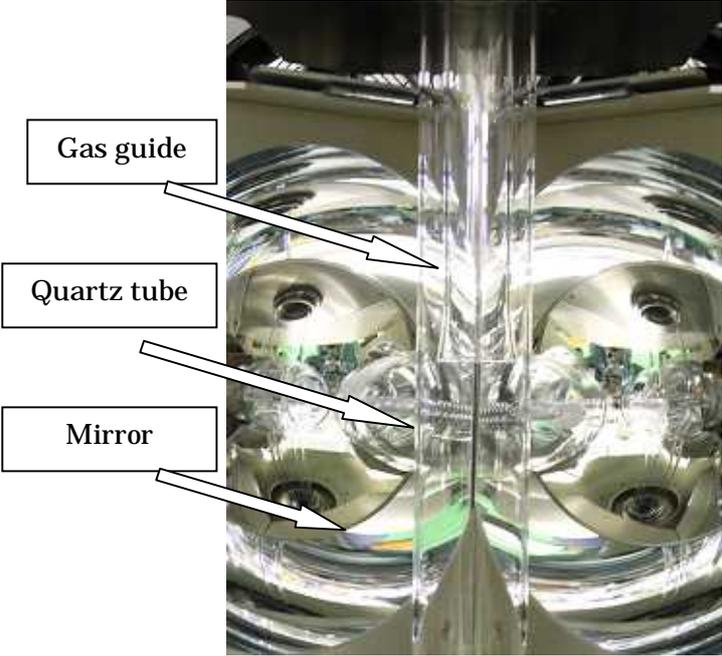


Fig.7 Feature of the gas guide inside the quartz tube