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GROWTH OF Si SPHERICAL CRYSTALS AND THE SURFACE OXIDATION
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Nearly 90% of semiconductor devices are produced with Si single crystals as the starting materials. For instance, the integrated circuits (IC), which are used in almost all electronic equipments such as TV, tape recorders, audio amplifiers, etc., are made after various processings of Si single crystal wafers. In these wafers, the same controlled amounts of impurities are added and the uniformities in their distributions are extremely important.

Growth under microgravity makes it possible to eliminate the buoyancy-driven convection in the melt, which is one of the main origins of convections which results in non-uniformity of the impurity. Another source of convection is known as Marangoni convection which is driven on the free surface when a temperature gradient occurs. One of the merits of microgravity experimentation is that the detailed study of this convection becomes possible. Another important advantage of microgravity is that growth of crystals without a crucible is possible. This makes it possible to study melt growth without the strain which is usually introduced on the ground. Nevertheless, we should repeat and analyze many growth experiments in space to get reliable results. However, since in the FMPT, the time for the experiment is limited, we plan to carry out two kinds of very simple and basic experiments as the first step for the semiconductor growth experiment.

In the first experiment, we use single crystal Si sphere as the starting material and as shown in Figures 1 and 2, this sphere is heated in the furnace at a slightly higher temperature than the melting point. After the melting front moves nearly half way to its center, the temperature is decreased to stop the melting and to start the growth from the seed for which we use the unmelted solid part of the sphere. The sphere is centered by quartz protuberances inside of the quartz crucible. There exists the possibility of temperature fluctuations being introduced when the molten sphere occasionally touches the protuberances. The total time needed for the melting and the growth processes is estimated to be 30 minutes. Infrared emission from the sphere is monitored in order to prevent the accidental loss of the central solid core.

The schematical illustration of the second experiment is shown in Figure 3. Here, a single crystal, Si rod is used as the starting material. In the first stage, the rod is melted from one end to obtain a liquid sphere. In the second stage, the single crystal is grown by decreasing the temperature from the unmelted part of the rod which is used as the seed. The second experiment somewhat resembles the Czochralski method used on the ground; however, in the space experiment, no crucible is employed and the temperature uniformity is much superior.

In both experiments, phosphorus is doped to allow observation of the change in the shape of the liquid solid interface during crystal growth and the impurity striations, if any.

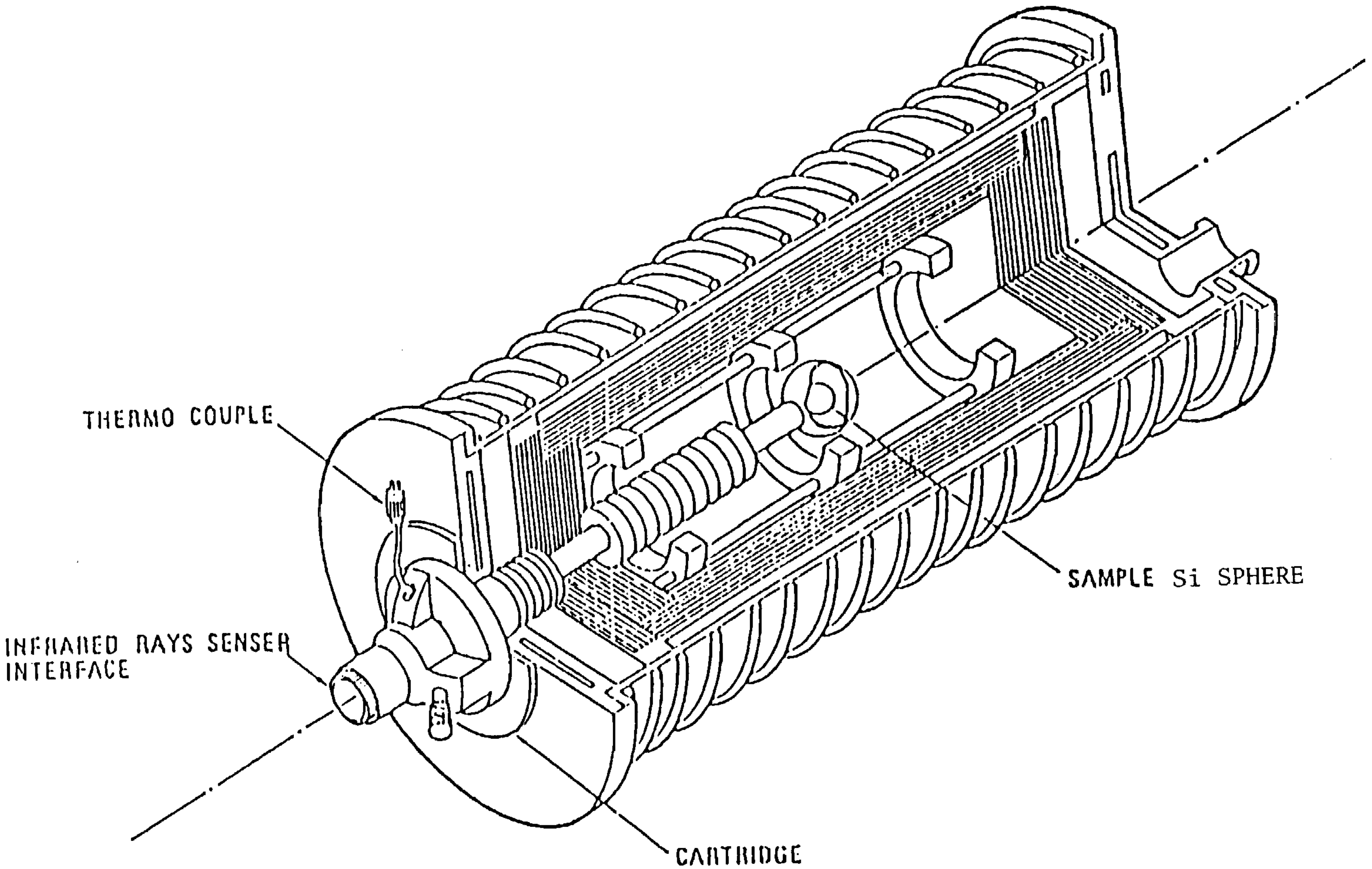

Figure 1. Crystal Growth Experiment Facility concept.

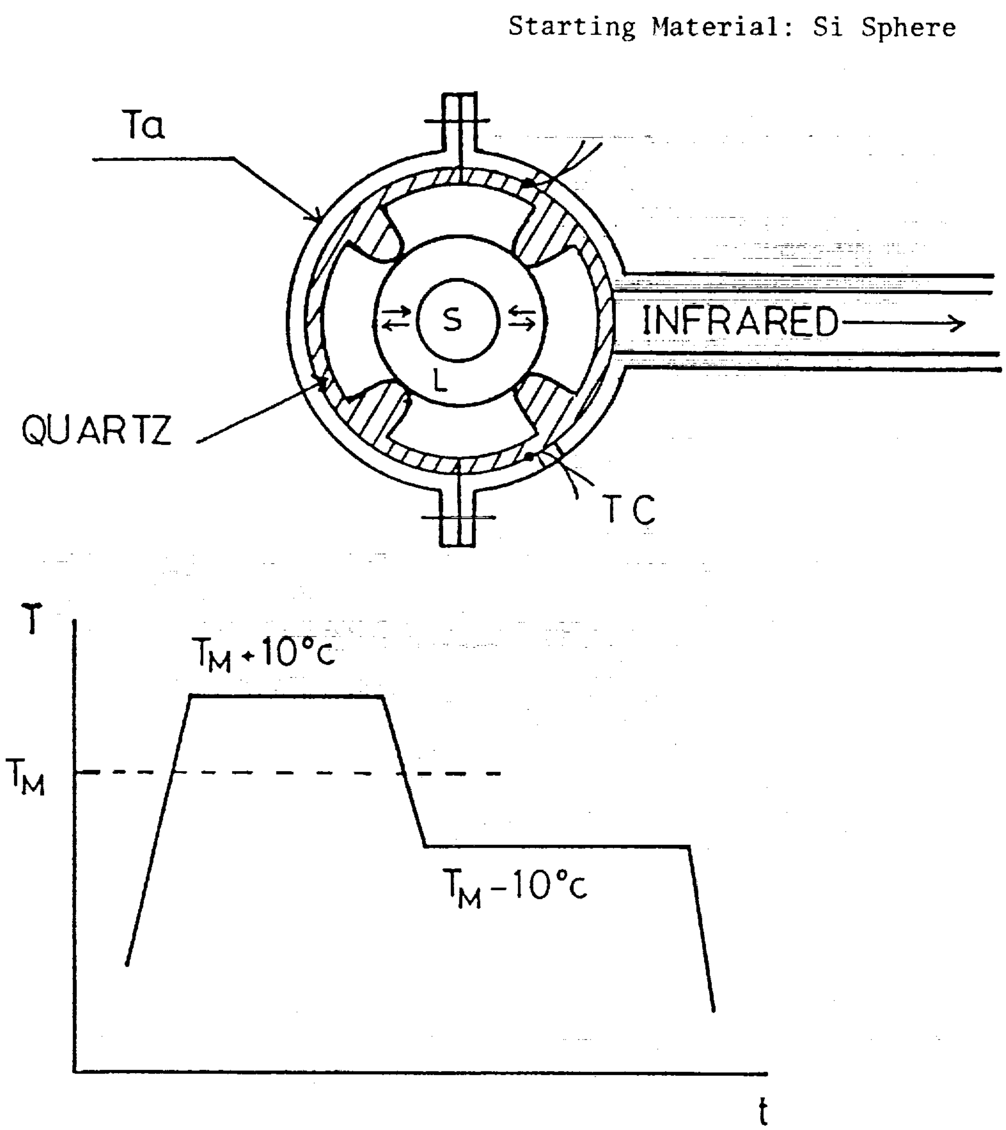

Figure 2. Growth of spherical crystal.

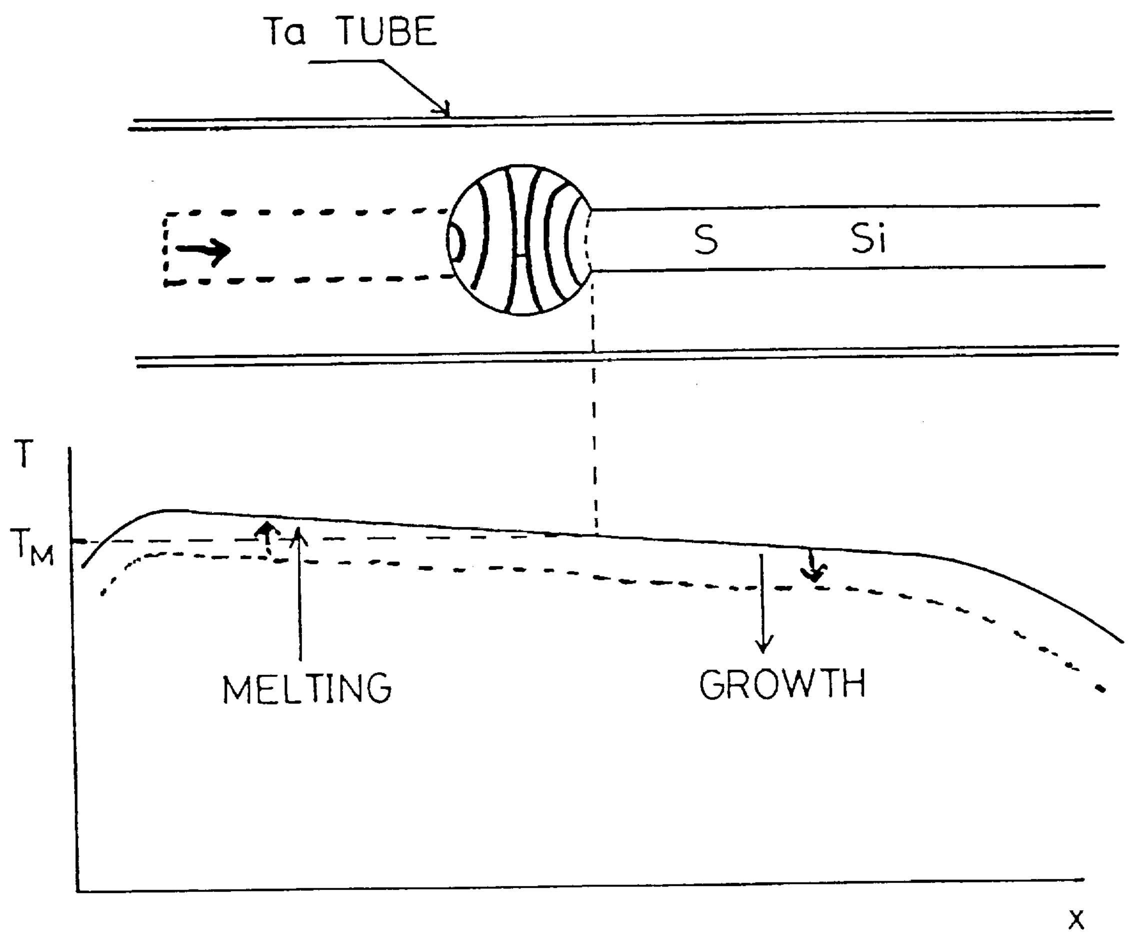

Figure 3. Growth of HEMI-spherical crystal with external seed.