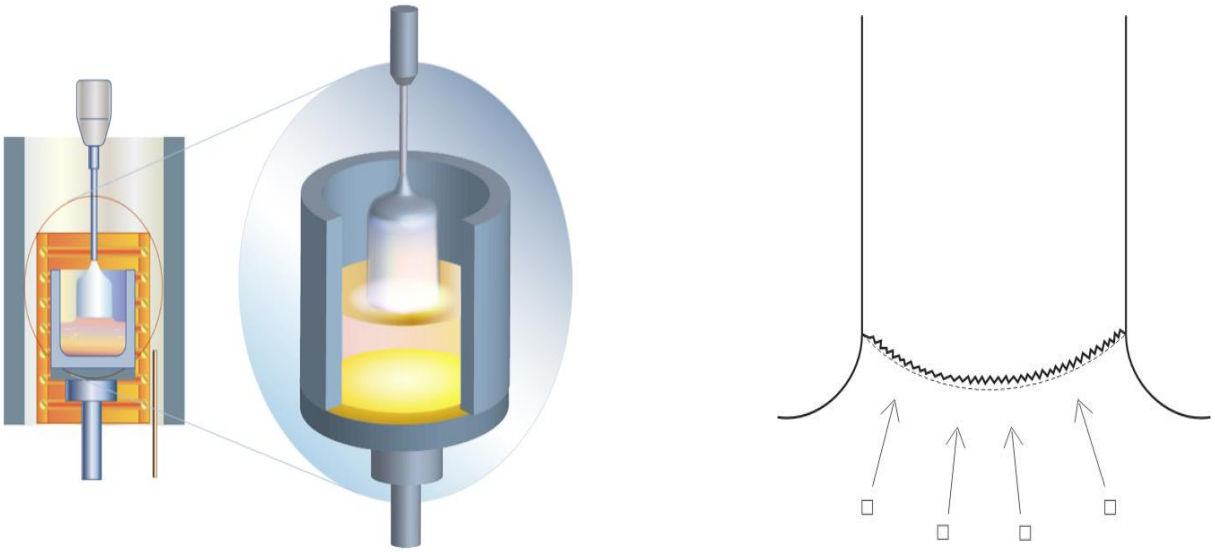
Low Temperature Gradient (LTG) Czochralski method advantages

Our company made a significant modification in the Low Temperature Gradient (LTG) Czochralski method to grow crystals from melt.

First modification of the Czochralski method appeared in the 80s of the last century at the Novosibirsk Scientific Center for growing large-sized multicomponent crystals with volatile components, such as molybdates, tungstates and germanates.

In the traditional Czochralski method - pulling crystals from the surface of the melt in an open crucible, the temperature gradients in the melt are in the range of 10-100 ° C / cm, the crystallization front corresponds to the isotherm at the interface, where the normal growth mechanism is realized (along the normal to the isotherm) with the formation of rounded atomic-rough surfaces



(traditional Czochralski method picture and crystal with mechanism of growing)

In this case, the shape of the crystal is round, there are always defects in the form of macroinclusions in the central part of the crystals (growth column) and a large number of dislocations due to thermoelastic stresses associated with high temperature gradients.

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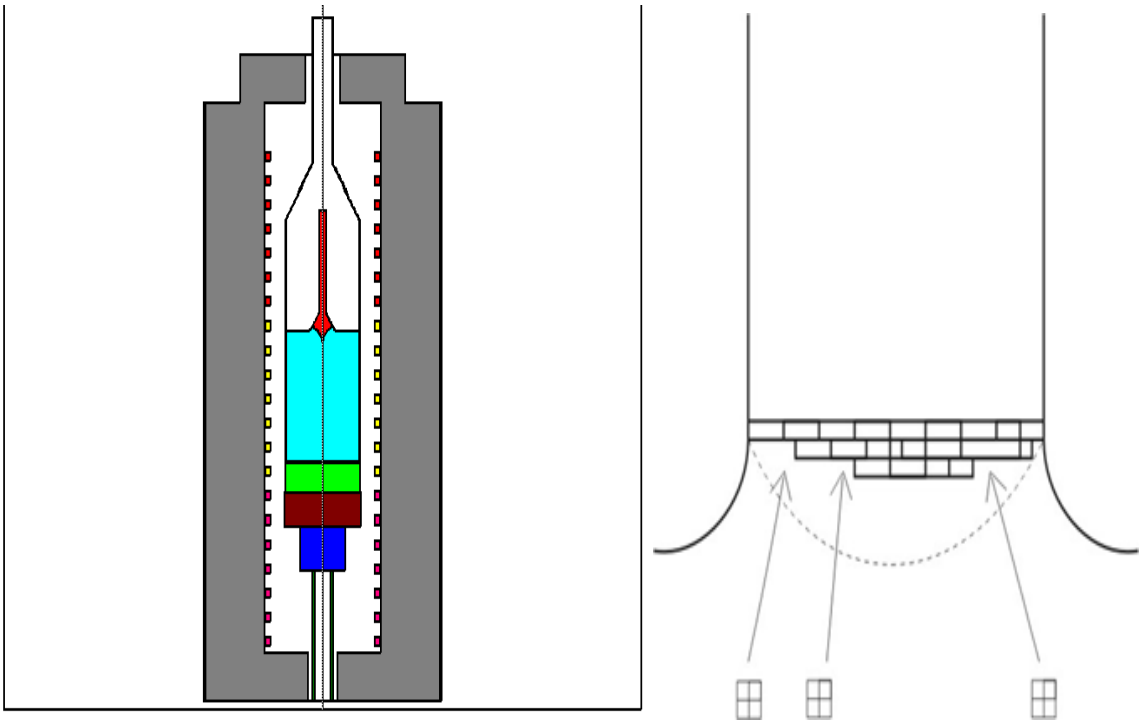
The yield of a useful product from the initial charge is low, since the volatilization of the melt components during the growth process leads to a shift in the stoichiometry of the grown crystal. For example, for tungstates and molybdates grown by the traditional Czochralski method, the utilization rate of the load does not exceed 40%.

The disadvantage of this method is its energy consumption and high consumption of coolant. The advantages include simplicity of process control (usually visual control by the operator) and high crystallization rate (up to 10 mm / h).

In the Low Temperature Gradient (LTG) Czochralski method, the pulling of crystals from the surface of the melt is carried out in a semi-closed elongated crucible, in a multi-zone furnace with increased thermal insulation, temperature gradients in the melt are reduced to a level not exceeding 1 ° C / cm, the crystallization front is polyhedral, the surface is atomically smooth, corresponding to the crystallographic plane -faces, according to the crystal symmetry. The front is formed by the layer-by-layer growth mechanism, tangentially (at an angle to the isotherm).

The temperature difference between the isotherm (corresponding to the melting point of the crystal) and the surface of the crystallization front (atomically smooth face of the crystal) corresponds to the supercooling required for the formation of conglomerates of crystal atoms (nuclei of the required size) with the surface energy corresponding to the energy of step steps on the face where they are embedded. Important! Since this surface energy is low, heat fluxes setting temperature gradients of more than 1 ° C / cm lead to the loss of stability of the atomically smooth face and a change in the growth mechanism from layer-by-layer to normal. Thus, the crystallization rate in this method usually does not exceed 2 mm / h.



(picture of LGT Czochralski method and crystal with layer-by-layers mechanism of growing)

In this case, the shape of the crystals is polyhedral, with developed faces at the growth front, there are no macroinclusions, the number of dislocations is minimal (usually no more than 100 pcs / cm 2), the stoichiometry of the crystals is not violated, the yield is up to 98% of the loading of the starting materials. The growing process, due to low heat loss, is energy-saving (energy consumption is reduced by an order of magnitude, compared to traditional methods), the cooling system is closed and does not require the consumption of cooling liquid.

The advantage of this method is its applicability to any crystals with a melting point of up to 1300 ° C and the ability to grow large crystals (50 kg or more).

At the same time, the control system is complex, requiring precision scales of blocks and original software, which includes data on the mandatory mathematical modeling of the growth process of a particular crystal.