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Effects of melt depth on oxygen transport in silicon crystal growth with continuous-feeding Czochralski method

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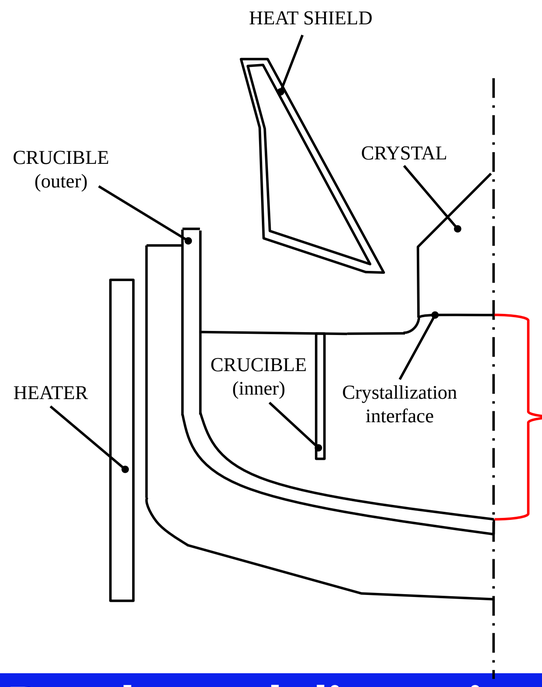
Introduction

The Lower melt depth means the lower oxygen concentration ?

- The depth of the melt in the crucible remains constant in the CCz growth process, because the polycrystalline silicon granules are continuously supplied to the melt surface as the silicon rod is being pulled.
- A new source of oxygen impurity is introduced by double crucible system in comparison to the conventional CZ method;
- However, we did not find any literature about the effects of melt depth on oxygen concentration in the melt during the CCz growth process. **The lower melt depth means that the area of the crucible where oxygen impurities are dissolved is smaller, so is the crystal oxygen impurity content lower?**
- Therefore, it is necessary to study the effects of melt depth and double crucible design on oxygen transport in the CCz-Si crystal growth.

Model description



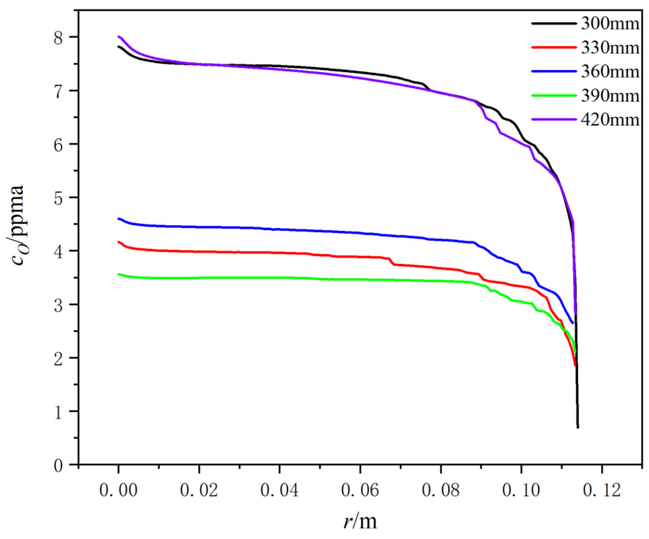
Crystal rotation rate : 8 rpm
Crucible rotation rate : -4 rpm
Pulling rate : 1.2 mm/min

2D global heat and mass transfer model
In-house software (CGeMoS)

- The study has simulated at melt depths of 300mm, 330mm, 360mm, 390mm and 420mm, respectively.

Results and discussion

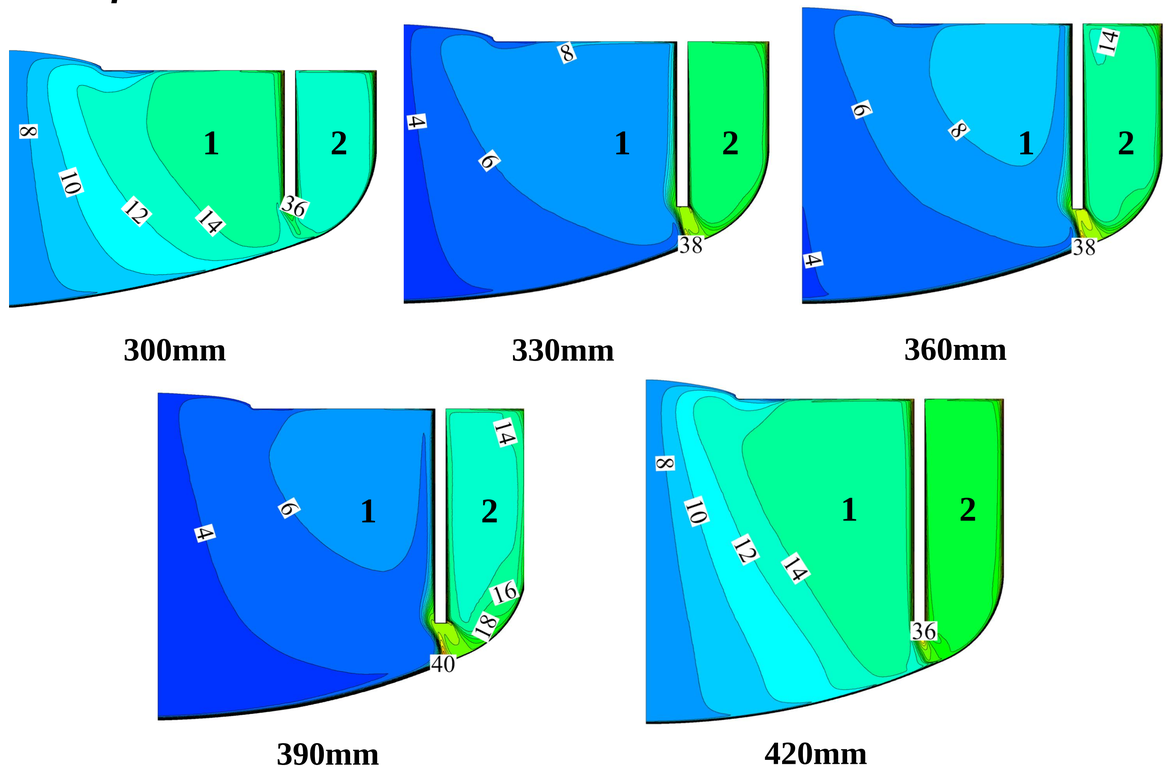
◆ Comparison of O distribution at the m-c interface



- The oxygen impurity content at the m-c interface of the 300mm/420mm melt depth is much more than that of the 330-390mm depth.
- There is a critical value of melt depth, which can produce the lowest concentration of oxygen impurity.

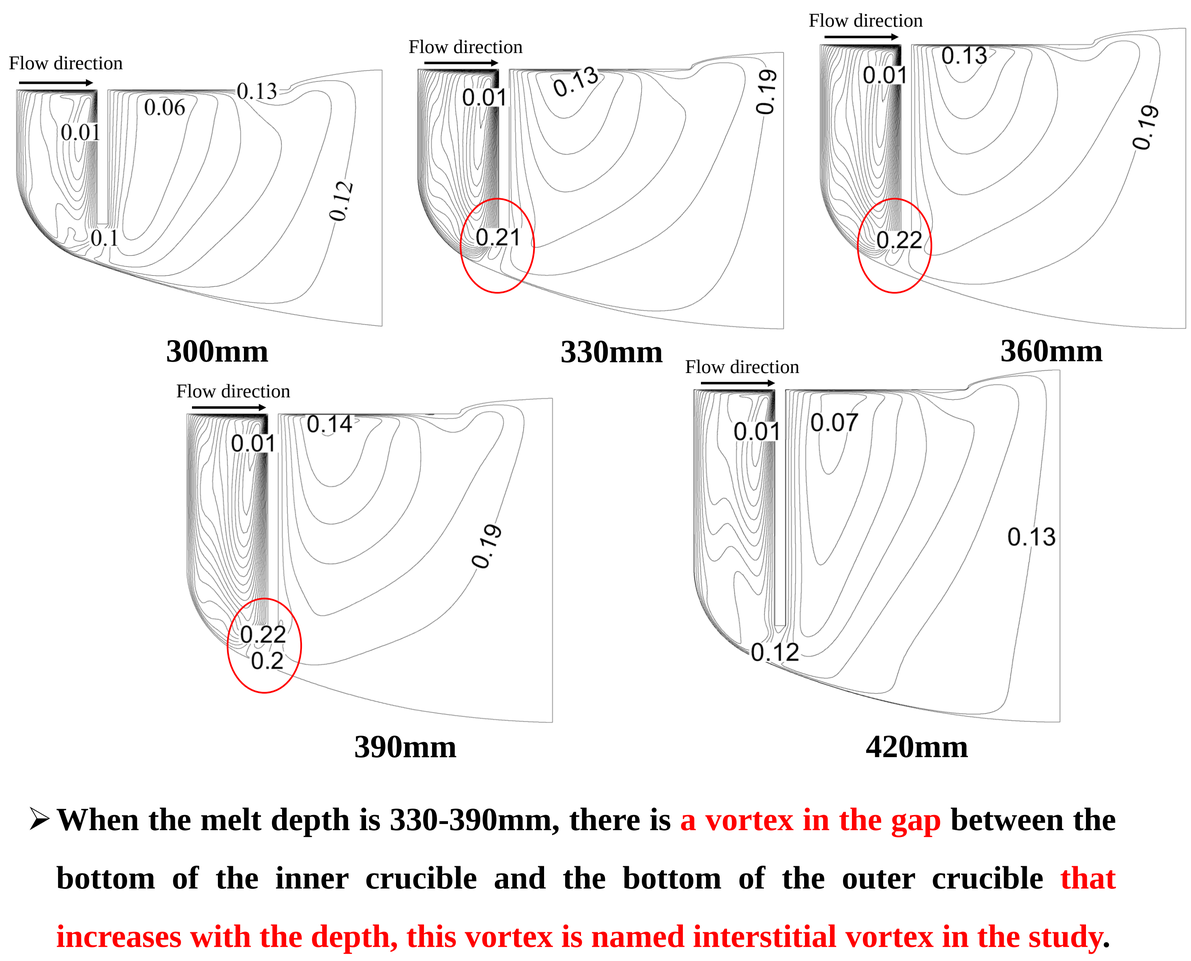
When the melt depth is the lowest, the oxygen impurity content is the highest, why ?

◆ Comparison of O distribution in melt



- The content of oxygen impurities in the zone 2 is the highest, **the inner crucible blocks a large amount of oxygen impurities in this area.**
- The oxygen impurity concentration in zone 1 with melt depth of 300mm/420mm is higher than that of melt depths of 330mm, 360mm and 390mm, but the oxygen impurity concentration in zone 2 is the opposite.

◆ Comparison of stream function in melt



- When the melt depth is 330-390mm, there is **a vortex in the gap** between the bottom of the inner crucible and the bottom of the outer crucible **that increases with the depth, this vortex is named interstitial vortex in the study.**
- The interstitial vortex prevents the transfer of oxygen impurities from zone 1 to zone 2.
- When the melt depth is 300/420mm, there is no interstitial vortex, so the oxygen impurity content is the highest.

Conclusions

- **When the design of inner crucible remains unchanged, there is a critical value of melt depth, which can produce the lowest concentration of oxygen impurity.**
- **The interstitial vortex can be created by the inner crucible design, which can block most of the oxygen impurities from transporting to the m-c interface.**