Quality aspects of Siemens-rods for FZ crystallization

Michael Schley, Friedrich Schaaff, Marcus Gartenbach
Silicon Products Bitterfeld GmbH&Co.KG, Alu-Strasse 5, D-06749 Bitterfeld-Wolfen, Germany
www.silicon-products-gmbh.com

Aim and Outline

The main aim of this investigation is to gain more understanding in the production of Siemens-rods for FZ crystallization. Process conditions and impurity related defects in the feed Siemens-rods are of high importance for its success. Siemens-rod growth structure features like voids, particles, poor slim rod – growth layer interfaces and changes in grain size structures influence the FZ crystal growth. A good process control is needed in order to achieve homogenous grain structures at high deposition rates.

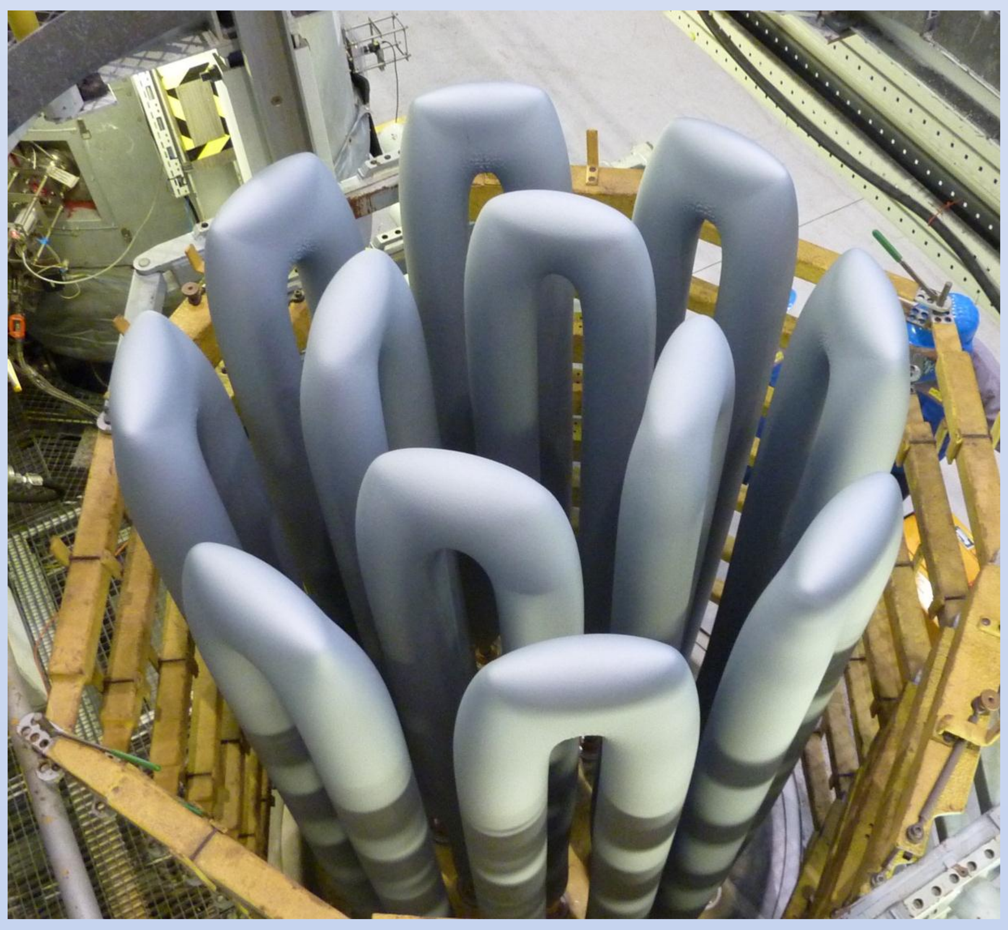
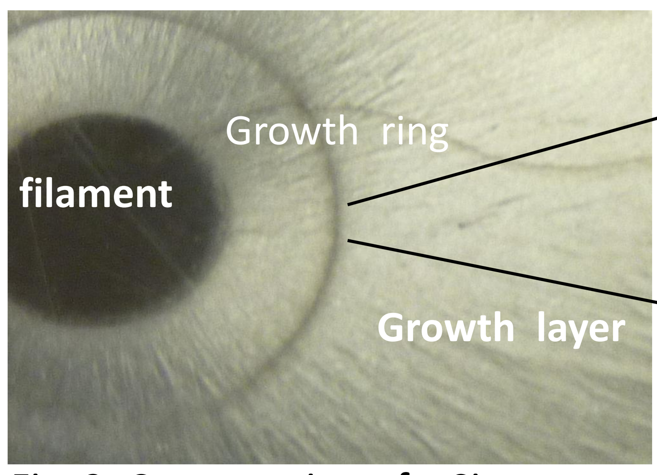


Fig. 1: Fz quality Siemens rods from SPB

Methodology

Grain structure analysis of a Siemens-rod was carried out in order to characterize defects in Siemens-rods by microscopy.

Example 1: Growth Ring



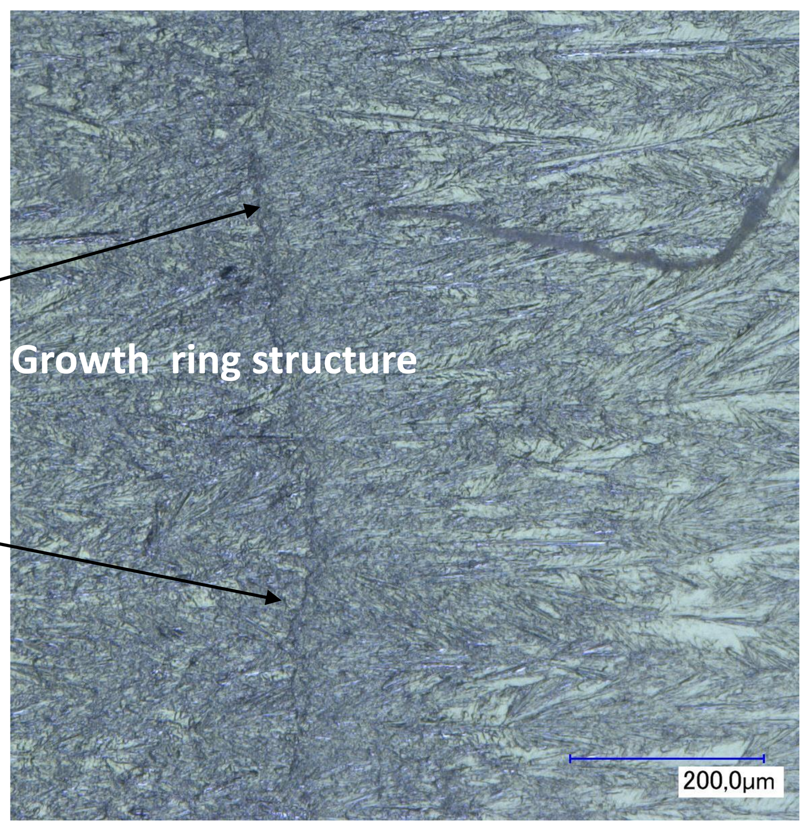


Fig. 2: Cross section of a Siemens-rod with growth ring
Fig. 3: Ring at higher magnification

In an experiment the silicon deposition was aborted and then restarted to simulate extreme changes in process conditions and their effects on the silicon quality. One can see the structural change from the deposited growth layer on the picture of the cross section of the feed Siemens-rod [Fig. 2]. A so called growth ring can be seen at the expected radius corresponding to the process restart. The structural effect can be observed as an about 300 µm thick change in the grain size distribution. [Fig. 3] shows a microscopic image of the ring structure.

Example 2: Slim rod - growth layer interface

One of the important structural properties of a Siemens-rod is the interface between the slim rod and the growth layer. An oxide layer at the interface can be present. This oxide layer can avoid mono-crystalline growth during crystallization. Figure 4 depicts a 20 µm thick trench after etching likely caused by the oxide layer between the slim rod and the growth layer. By adjusting the process conditions no trench formation after sample preparation (no oxide layer) can be found [Figure 5] with the optical microscope.

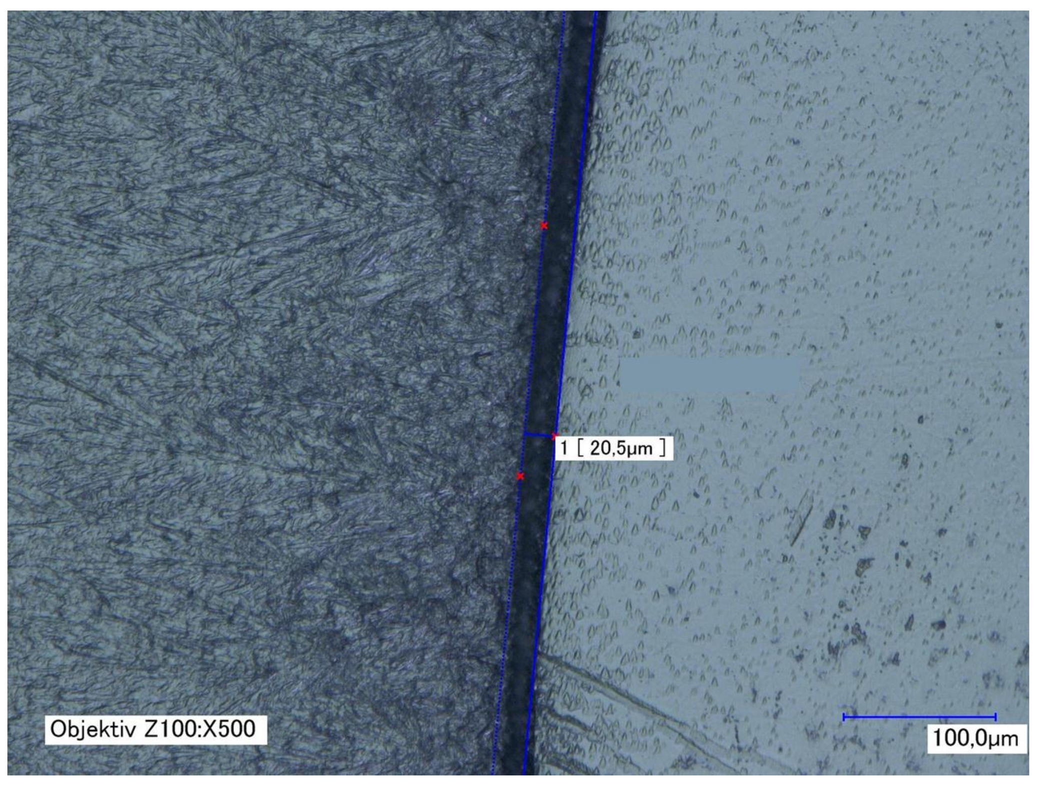


Figure 4: Poor interface layer

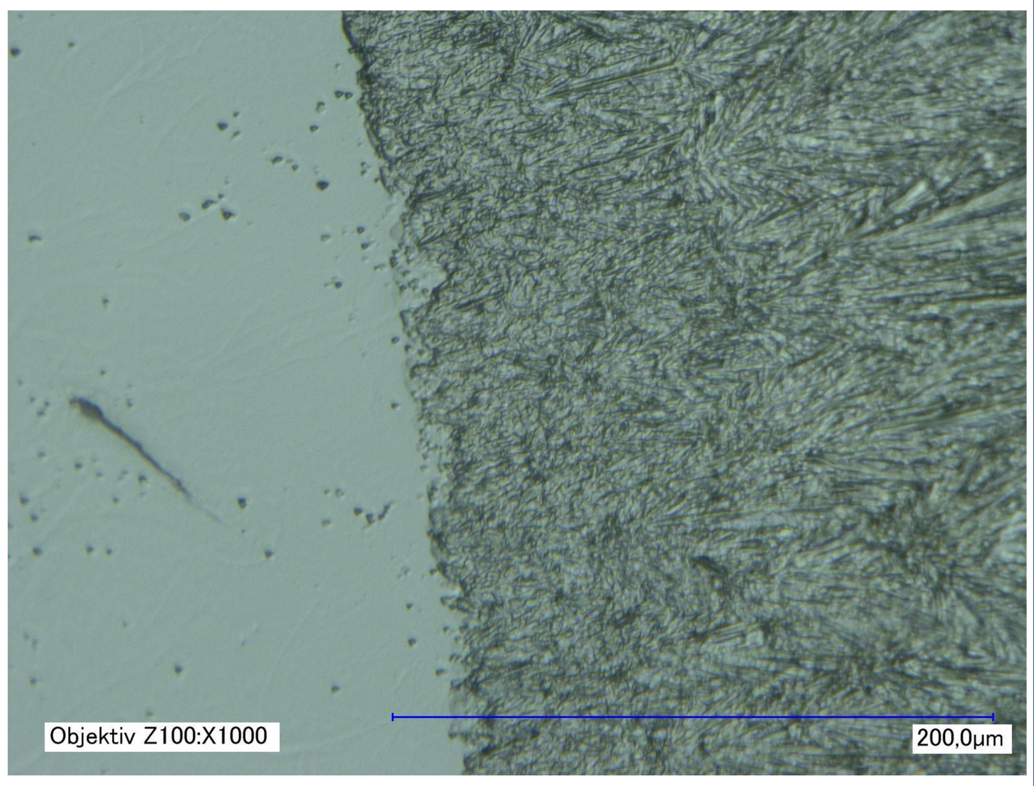


Figure 5: Excellent interface layer

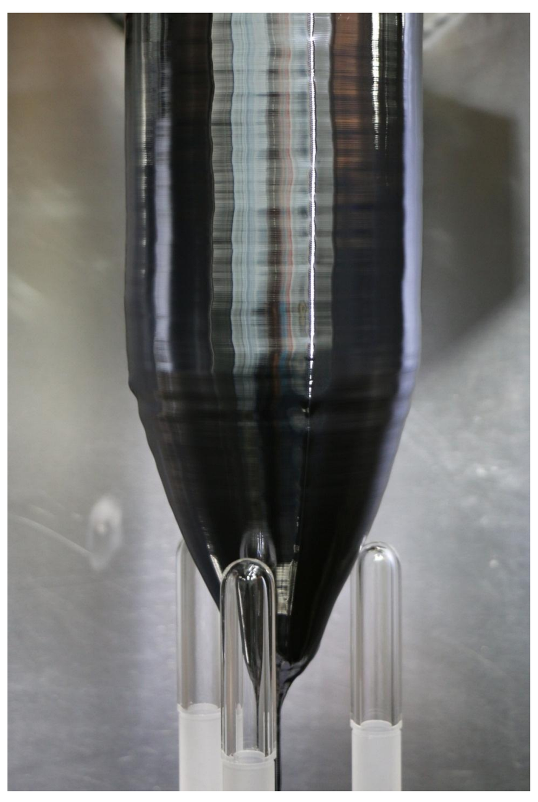


Figure 6: FZ single crystal

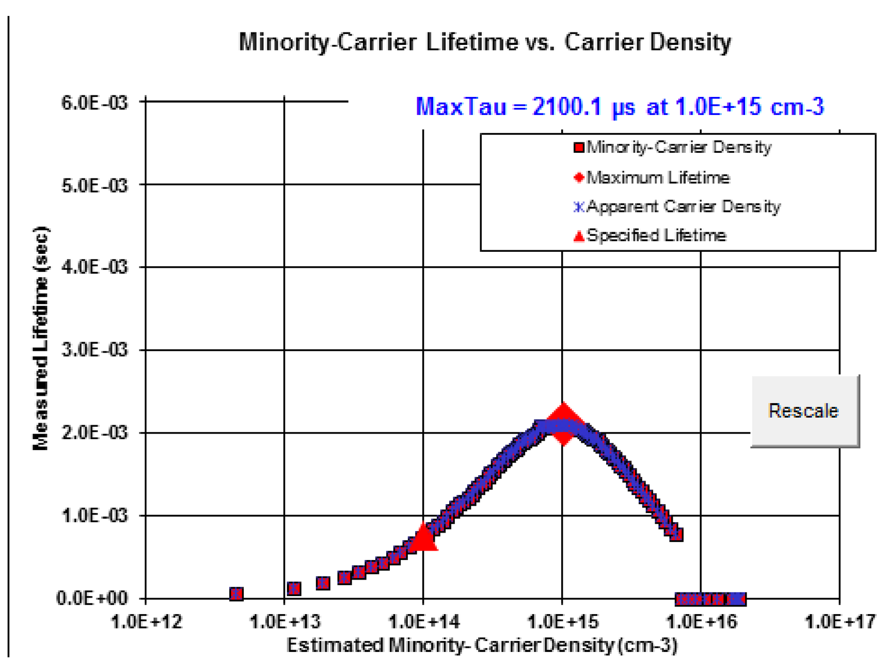


Figure 7: Lifetime measurement of the FZ rod

Conclusion

Through process optimization of the Siemens-deposition and quality improvements of the chlorosilanes, equipment and Silicon handling at Silicon Products poly silicon rods were produced which are suitable for FZ crystallization. It was possible to grow a 4" 300 mm long FZ single crystal [Figure 6].

A specific resistivity of more than 2000 Ω*cm was achieved with Silicon Products silicon. This proves the very low concentration of dopants in the Siemens-rod. Corresponding lifetime measurements showed 2100 µs which confirm a low level of metal contaminants (See [Figure 7]).