REMELTING AND PURIFICATOIN OF Si-KERF FOR PV-WAFERS

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Abstract:

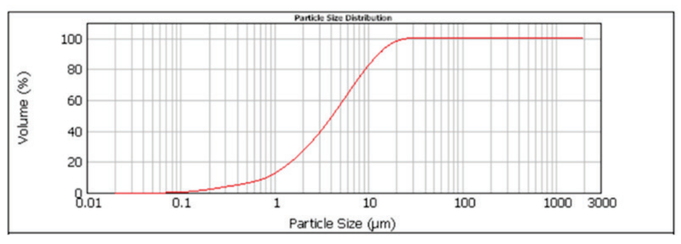
Kerf from slurry based wafer cutting has undergone several refining steps and remelted into ingots for PV-application. The ingots has been wafered and characterized and show satisfactory quality.

1. Introduction

During production of silicon wafers in the step between silicon ingots to wafers, about 40 – 50 % of the material is lost due to the cutting technique. Due to the cutting technique, this silicon is in the form of particles with size from 1 – 100 µm. In addition, for slurry based cutting, the silicon particles are mixed with SiC-particles and PEG (Polyethylene glycol). The silicon in the slurry has to be separated from the SiC-particles and PEG. This is done in several steps, each step giving more and more pure silicon material. Finally, the material should be pure enough for directional solidification and production of new PV-wafers.

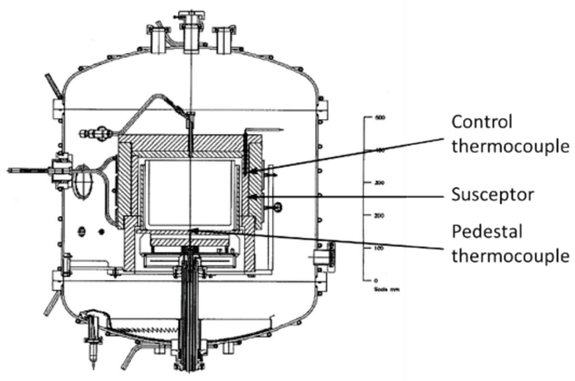
2. Material and experimental setup

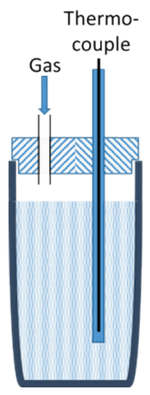
Silicon particles from wafer cutting is processed by ReSiTec and delivered to SINTEF for crystallization tests. Size distribution and typical analysis (XRF) of the powder are:



Si (%)	> 99.7
Fe (ppm)	400
Al (ppm)	800
Ca (ppm)	60

The Crystalox DS250 furnace at SINTEF was used for the tests with directional solidification. The furnace produce 12 kg ingots.

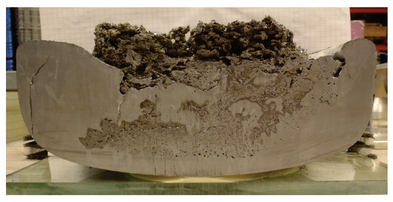




An inductively heated furnace with graphite crucible and lid is used for melting and refining, and a Crystalox DS250 furnace is used for directional solidify-cation. The chamber above the charge is continuously flushed with argon to minimize oxida-tion.

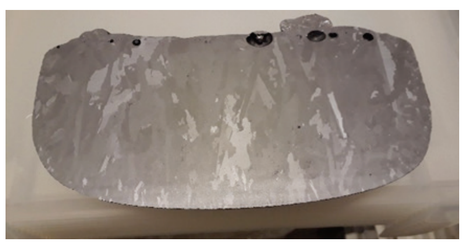
3. Results

1st test: Two ingots were produced in the Crystalox DS250 furnace with-out any refining of the pow-der. A cut plane of the one of the ingots is shown to the right.



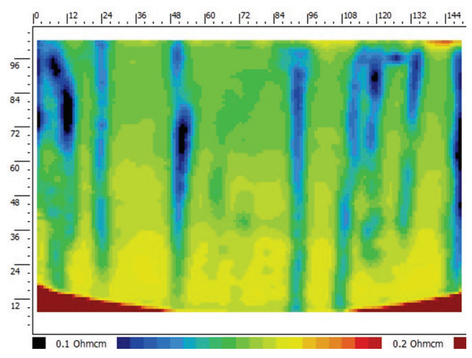
3. Results (cont.)

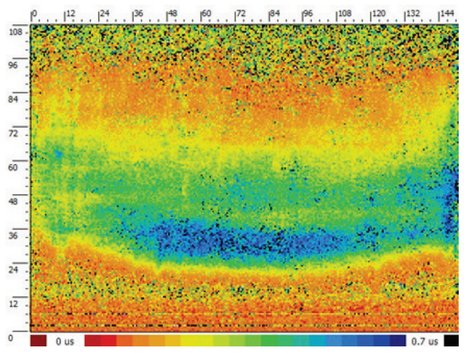
2nd test: The powder was first melted in graphite crucible and poured into a silica crucible. Inclusions sticked to the wall of the graphite crucible. The material yield in this step was 85 – 90 %. This material was used to produce one ingot with 10 % refined material (below left) and one ingot with 100 % refined material (below right).



The 10 % ingot showed normal grain structure whereas the 100 % ingot had lost the planar crystallization front due to too high impurity level.

The two ingots with refined material was cut into bricks and sent to Fraunhofer THM for characterization and wafering. The resistivity (left) and lifetime (right) maps of the side of the 10 % ingot brick are shown below.





The table below shows ICP-MS analysis (in ppm by weight) of two positions of first ingot and two positions of the ingots with 10 % refined material. Boron was deliberately added to the 10% ingot to make resistivity of about 1 Ωcm. Some of the other elements show good removal efficiency in the refining step.

	B	Na	P	K	Ca	Fe
Top 1st ingot	-	150 ± 20	2 ± 1	105 ± 11	660 ± 180	142 ± 4
Bot 1st ingot	-	22 ± 10	0.9 ± 0.1	4 ± 7	520 ± 150	1.1 ± 0.7
Top 10%	1.9 ± 0.2	9.3 ± 1.6	0.6 ± 0.3	2.5 ± 3.8	19 ± 31	2.3 ± 2.1
Bot 10%	1.7 ± 0.3	14 ± 2	0.3 ± 0.5	2.8 ± 1.4	8.7 ± 4.8	5.0 ± 0.5

4. Conclusions

- Refining of the silicon powder by melting and separation of inclusions must be done if should be used as feedstock for PV-material.
- By melting the powder in a graphite crucible and pouring it into an other crucible, the majority of inclusions remains in the first crucible by sticking to the crucible walls.
- The refining process demonstrated gave 85 – 90 % material yield.
- The refining also removed large fraction of many of the elements.

Acknowledgements

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