Improved crucible- and coating quality will give better silicon solar cells

Multicrystalline silicon ingots for solar cell production are normally cast in silica crucibles coated with silicon nitride.

A crucible with silicon charge can be seen in Fig. 1. The silicon nitride coating prevents reaction between the silicon melt and the crucible and acts as a diffusion barrier to prevent impurities from the crucible to contaminate the melt. Both the crucible and the coating are sources of contamination of the silicon and improving the purity of crucible and coating has the potential of improving the minority carrier lifetime of the ingot material and the efficiency of the solar cells. This potential has been investigated in cooperation with Vesuvius, a crucible producer. Standard solar grade silicon has been cast in a pilot sale furnace with crucibles and coatings of different purity. A crucible made from high purity silica and a crucible produced from standard grade silica but with a layer of high purity silica located between the crucible and the silicon nitride coating has been tested. In addition, a new Ready-To-Use crucible (RTU) with a mechanically resistant silica layer on top of the silicon nitride, with improved loading and transfer condition has also been tested. The minority carrier lifetime and cell efficiency has been used to evaluate the quality of the resulting ingots and have been compared to that of ingots cast in reference crucibles.

It has been found that the purity of the crucible and coating has a significant effect on the lifetime. A higher purity crucible and –coating will double the lifetime of the ingots over ingots cast with reference grade crucible and coating as can be seen from Fig. 2. In the Ready-To Use crucible, where an oxide layer is facing the melt, the oxygen concentration of the ingot has been increased due to the dissolution of the oxide layer which has reduced the lifetime, but cells produced from this ingot still has an acceptable efficiency.

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Photo: Rannveig Kvande

Fig. 1
Silica crucible for solar cell ingot production during charging with silicon feedstock prior to melting.

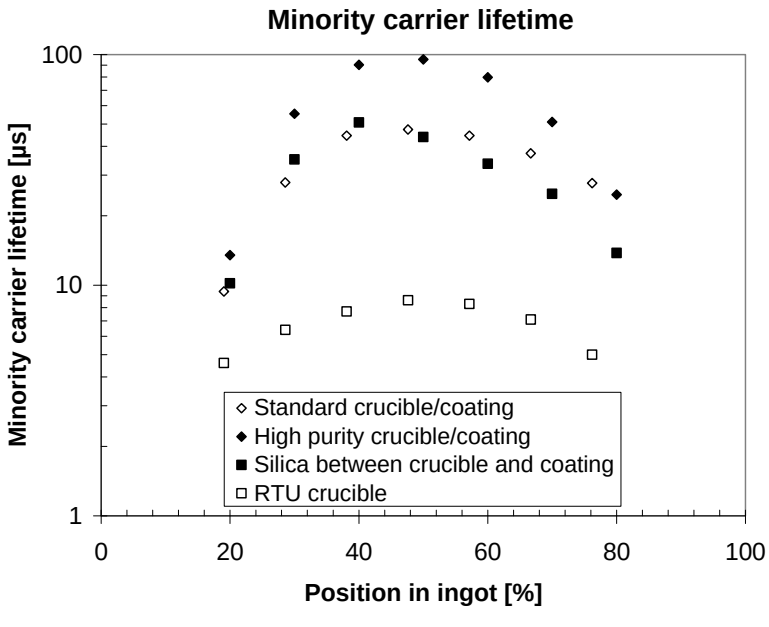

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Fig. 2
Carrier lifetime as a function of vertical position in silicon ingots cast in different crucibles. A high lifetime is necessary for good solar cell performance.