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ADVANCING MATERIALS, ADVANCING TECHNOLOGY

White Paper: Granular consolidation and calculation method for acceptors/donors and carbon

Granular polysilicon is used as the feed stock for the growth of large single crystal ingots by Czochralski (CZ) method and large multi-crystalline ingots by the directional solidification method. These ingots are often intentionally doped during the crystal growth to the desired resistivity and type (P or N) so the dopant levels in the feed material must be known to calculate the amount of dopant to be added. The following methodology is used to measure dopant levels (B, P) and other non-metals (C, O) for REC granular polysilicon.

Measurement

To measure the levels of non-metals (B, P, C, and O), granular polysilicon is melted in a quartz crucible without contacting the crucible walls and a small diameter single crystal is pulled from the melt by using the Czochralski (CZ) method. This process is performed under argon gas to prevent contamination from the environment. The single crystal ingot pulled constitutes small fraction (<15 wt%) of the melt to prevent saturation of the melt by carbon to its solubility limit.

Two small discs, as shown in the figure, are cut from the ingot for analysis by using a diamond saw at "seed end" and "tang" positions. The "seed end" and "tang" positions correspond to 0.016 and 0.105 mass fractions of the melt, respectively. The discs are acid etched and rinsed to remove contamination from the saw before analysis by Low-Temperature Fourier Transform Infrared Spectroscopy (LTFTIR).

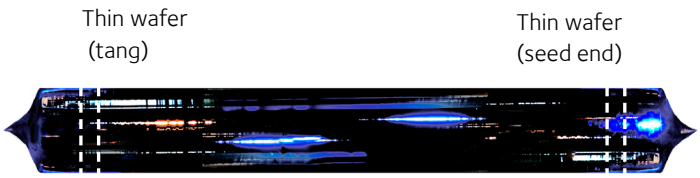
The two discs are analyzed for B, P, C and O by using LTFTIR and results are reported as "in the ingot" as ppba for B, P and ppma for C and O. If desired, the levels of non-metals in the granular material can be calculated from the mid or tang values by using the CZ mass balance equation:

$$CS(f)=k*Co*(1-f)^{(k-1)}$$

f = fraction of the melt solidified, given above
CS(f) = concentration of impurity in the solid
CL(f) = concentration of impurity in the liquid
k = equilibrium segregation coefficient
Co = concentration of impurity in the original mass

IMPURITY	EQUILIBRIUM SEGREGATION COEFFICIENT, K*
Boron (B)	0.80
Phosphorus (P)	0.35
Carbon (C)	0.07

*For carbon "Effective segregation coefficients" should be used when available. For B and P, equilibrium segregation coefficients give satisfactory results.



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REC Silicon is a leading producer of advanced silicon materials, delivering high-purity polysilicon and silane gas to the solar and electronics industries worldwide. High-purity Signature Silane® gas (SiH_4) is central to the quality and consistency of all the company's materials. The company combines 25 years' experience and proprietary technology with the needs of its customers to provide value-added raw materials which are used to manufacture solar modules and silicon wafers. REC Silicon is the world's largest silane gas producer and one of the world's largest polysilicon manufacturers, with a capacity of more than 20,000 MT of polysilicon and 29,000 MT of silane gas annually from two US-based manufacturing plants. Listed on the Oslo Stock Exchange (ticker: REC), the company is headquartered in Moses Lake, Washington and employs 800 people.

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