

Potential of Si isotopic composition measurement for traceability of Crystalline Si wafers

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Photovoltaics is pivotal to the transition toward a low-carbon energy system. Nowadays, 95% of the worldwide photovoltaic production is based on monocrystalline silicon wafers [1] grown with the Czochralski technology. The question of the origin and the traceability of such strategic material is key. The methods to control and guarantee the traceability for Si materials are so far mostly declarative based, and there is clear need for analytical techniques to bring scientific proofs of the origin.

Inherited from the geosciences, non-traditional isotopes are now a tool of choice for proving the geographical origin of certain food products [2] or materials [3]. One of the most suitable technique for such isotopic analysis is MC-ICP-MS spectrometry. We optimized and compared two different analytical strategies for Si isotopic composition measurement by high resolution MC-ICP-MS. The first is bulk analysis with sample mineralization, sample purification and liquid introduction approach. The second is in-situ analysis by femtosecond laser ablation coupled to a MC-ICP-MS. Both methods demonstrate a great accuracy and an external precision better than 0.10‰ (2SD) for $\delta^{29}\text{Si}$ and 0.15‰ for $\delta^{30}\text{Si}$.

In this study, we analyzed monocrystalline Si wafers from seven different suppliers worldwide. The results show specific Si isotopic compositions depending on suppliers, with differences in $\delta^{30}\text{Si}$ up to 3 ‰. In addition, we analyzed several wafers lot from the same supplier produced with different growing conditions giving significant differences (up to 1.5‰ in $\delta^{30}\text{Si}$) that might be related with mass dependent isotopic fractionation occurring during the producing process.

[1] M. Fischer (2024), *International Technology Roadmap for Photovoltaics 15th edition*. VDMA

[2] C.Baffi & P.R. Trincerini (2016) , *Eur. Food Res. Technol.*

[3] Desaulty et al. (2022), *Nature communications*