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Characterization of multicrystalline silicon for photovoltaics by methods of neutron activation analysis

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The improvement of solar cells by achieving higher efficiencies and lower production costs is getting more important because of the worldwide increase of photovoltaics as a renewable energy source. In this framework, the aim of DFG-Project HA 5471/4-1 (Department of Nuclear Chemistry, Johannes Gutenberg-University, Mainz, "Fraunhofer Institute for Solar Energy Systems"(ISE), Freiburg) is to optimize the methods of manufacturing and analysis of solar silicon.

One manufacturing method is the directional solidification of raw and partly purified silicon (called "feedstock"). Based on their lower segregation coefficients, the impurities accumulate in the liquid stage during the solidification. The so produced silicon has acceptable concentrations of impurities and is called "solar grade silicon"(SoG-Si). For the analyses by means of Instrumental Neutron Activation (INAA) and Prompt Gamma Activation (PGAA) samples from SoG silicon as well as from highly purified silicon after the final solidification step are irradiated at three different research reactors: TRIGA Mainz, BR 2 Mol and FRM II Munich. Of special interest are the dopants boron and phosphorus and the 3d transition metals, which decrease the efficiency of solar cells by recombination of charge carriers. Profiles of these element concentrations in the produced silicon ingot as well as analyses of the impurity concentration in feedstock material and melting pot samples can help to improve the manufacturing method [1].

First results of measurements have shown a specific element distribution in produced silicon, caused by processes of diffusion and segregation [2]. Most of the elements, especially cobalt and boron, follow the Scheil-Equation [3] for distribution during directional solidification. With INAA the elements cobalt, iron, copper, chromium, antimony and scandium could be detected in silicon with a very low detection limit; with PGAA it was possible to measure boron at the ppb-level.

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[2] D. Macdonald, A. Cuevas, Transition-metal profiles in a multicrystalline silicon ingot, Journal of Applied Physics, 2005
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