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Characterization of silicon for photovoltaic applications with INAA and PGAA

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The required impurity level for silicon used in solar cell production can be much higher compared to the demand in the electronic industry [1]. Therefore processes are investigated to clean the raw silicon to an impurity level necessary for photovoltaic applications. Of special interest is the impurity level of the 3d transition metals and of the dopant element boron. Transition metals of the 3d –series form deep levels in the energy gap of silicon and act as recombination centres for the charge carriers thus degrading the efficiency of solar cells.
A major part of the purification of silicon takes place during directional crystallization because most impurities have a segregation coefficient k < 1 [2]. In order to find optimal crystallization parameters, the impurity profile along the crystallization front is of special interest. After cutting the ingots of multi-crystalline silicon into wafer further cleaning procedures like HCl gettering [3] are applied. In this procedure, a wafer is heated to temperatures above 600 °C at which a continuously streaming of inert gas (such as N2) or a reducing gas (H2) containing a few percent of HCl interacts with the wafer.
In this project, instrumental neutron activation analysis (INAA) is used to determine the 3d impurity concentration at the different purification steps beginning with metallurgical grade silicon (MG-Si) which is used as feedstock material for the crystallization and ending with the analysis of silicon wafers after the gettering procedures. Special attention is given to the impurity profile after crystallization. The neutron irradiation is carried out at the research reactor TRIGA Mainz [4] at a neutron flux from 0.7 x 10ˆ12 /cmˆ2s up to 4 x 10ˆ12 /cmˆ2s depending on the impurity level of the investigated material. The boron concentration was determined by prompt gamma activation analysis (PGAA) at the HFR research reactor in Petten.
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