Neutron transmutation doping of n-type spherical silicon solar cell at high-temperature engineering test reactor

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Abstract

This study proposed a new method of neutron transmutation doping silicon (NTD-Si) for producing the n-type spherical solar cell at the high temperature engineering test reactor (HTTR), in which the Si-particles are irradiated directly instead of the cylinder Si-ingot as in the conventional NTD-Si. By using a 'screw', an identical resistivity could be achieved for the Si-particles without a complicated procedure as in the NTD with Si-ingot.

Keywords: HTTR, MVP, NTD-Si, n-type silicon, spherical solar cell, high conversion efficiency

1. Introduction The p-type spherical silicon solar cell [1] (as shown in **Fig.1**) is a candidate for future solar energy with low fabrication cost, however, its conversion efficiency is only about 10%. The conversion efficiency of a silicon solar cell can be increased by using n-type silicon semiconductor as a substrate. However, it is difficult to apply a Czochralski method for growing a highly uniform n-type silicon semiconductor. Thus, this study proposed a new method of neutron transmutation doping silicon (NTD-Si) for producing the n-type spherical solar cell.

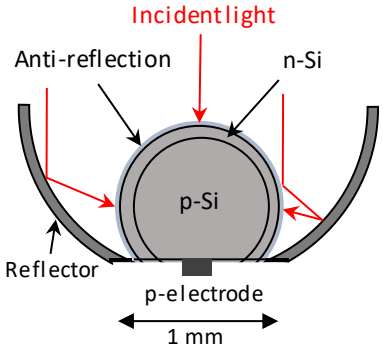

Fig.1 p-type spherical solar cell

2. Method A proposed scheme for NTD Si-particles is shown in **Fig.2**. The Si-particles moves circularly around the screw and from the top to bottom of NTD-hole by gravity. After being irradiated, the doped Si-particles are collected into the storage container by a suction tube for radiation removal. The neutronic calculations were performed with MVP-2.0 code and JENDL-4.0 library to estimate the resistivity of doped Si-particles. The configuration of the HTTR for NTD-Si was also optimized by changing the number of NTD-hole at replaceable reflectors from 3 to 12 and NTD-hole's diameter from 10cm to 25cm. The optimization of NTD-holes was carried out while keeping the decrease of k_{eff} less than 0.5 %Δk/k. The irradiation time was estimated to obtain 10 Ω cm of resistivity, which is suitable for fabrication of the solar cell.

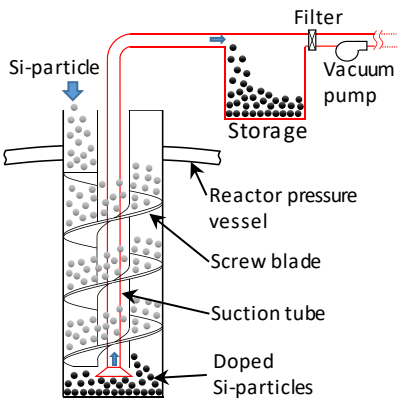

Fig.2 NTD-Si facility

3. Results and conclusions The optimum results with various number of NTD holes are illustrated in **Table 1**. In the case of 3 NTD-holes, 20 cm is optimum diameter which can produce approximately 39.6 ton/y of doped Si-particles. The irradiation time and reactivity insertion, in this case, are 42.4h and –0.5%Δk/k, respectively. The case of 6 NTD-holes with 10 cm diameter could produce 22.5 ton/y of doped Si-particles, while about 33.6 ton/y could be irradiated in the case of 9 NTD-holes with 10 cm. Besides, it is not feasible to use all of the 12 replaceable reflectors because the negative reactivity insertion is larger than 0.5%Δk/k. In conclusion, this study proposed the new NTD method for irradiating n-type spherical silicon solar cell at the HTTR, which is expected to achieve the low cost and high conversion efficiency in comparison with conventional silicon solar cell.

Table 1 Amount of 10-Ω.cm doped silicon in optimum cases

Num. of hole	D (cm)	Δρ (%Δk/k)	Irradiation time (h)	Mass of doped silicon (ton/y)
3	20	– 0.5	42.4	39.6
6	10	– 0.3	37.4	22.5
9	10	– 0.4	37.4	33.6
12	–	–	–	–

References

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