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New Design Concept of Neutron Screen for 8" NTD Irradiation in HANARO

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1. Introduction

HANARO has been providing the commercial NTD service for 8-inch silicon ingot in the NTD1 hole since 2010. The silicon Neutron Transmutation Doping (NTD) service is provided in reflector region of HANARO. Semiconductor produced by NTD is used in mass electric device and HANARO supplies 10~15% of world demand. To produce the semiconductor, the neutron screen method is adopted in HANARO NTD1 [1]. This paper comes up with an idea which is the new design concept of the neutron screen for the 8-inch silicon ingot in the NTD1 hole and calculates the viewpoint of the nuclear design.

2. Methods and Results

Fig. 1 shows existing neutron screen (Al screen, stainless steel screen and H_2O screen) of 8-inch NTD1 Si ingot irradiation device. The original 8-inch model has outer stainless steel screen and inner water gap screen in the middle part. Si ingot is placed in the inside of neutron screen.

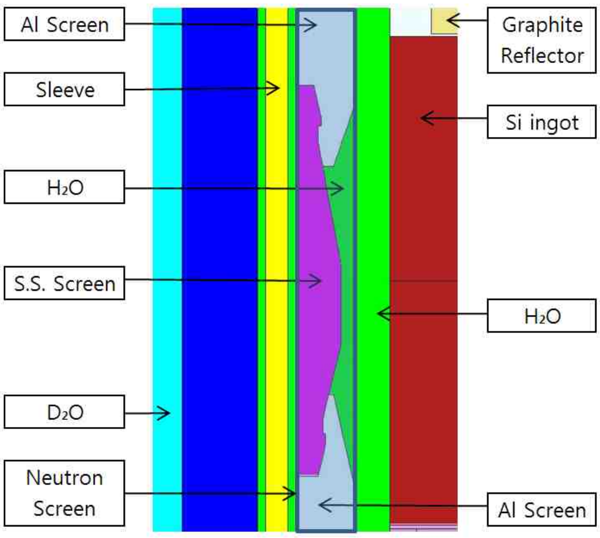

Fig. 1. 8-inch Si ingot and neutron screen inside the NTD1 Hole

Si ingot is usually loaded 2 or 3 ingots set which length is 20~30cm instead of 60cm ingot. This model has a water gap in the middle part; it is existed by between stainless steel and Si ingot. This water gap tends to induce an eccentricity of Si ingot.

Preventing this eccentricity, a plate spring is placed between the neutron screen and Si ingot. This plate spring could make the change of neutron flux. And Si ingot has a possibility of a demage from worn down by plate spring.

2.1 New Design Concept of Neutron Screen

In order to complement of existing neutron screen, we introduce new design concept of neutron screen which is reverse screen concept.

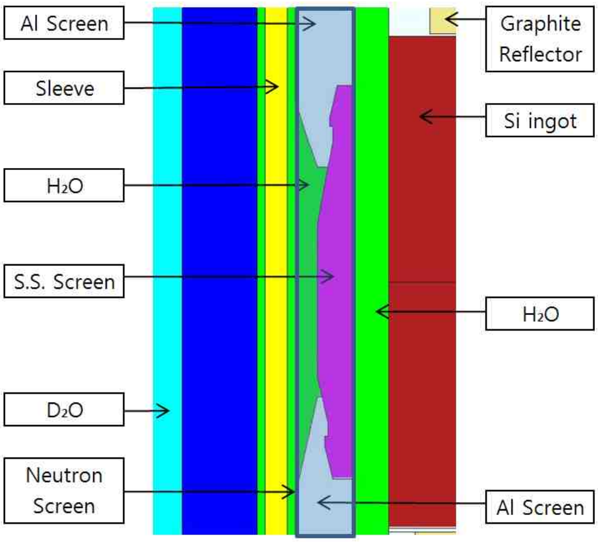

Fig. 2. New Design Concept of 8-inch Si ingot and neutron screen inside the NTD1 Hole

Fig. 2 shows the geometry of new design concept. It shows reverse position of stainless steel screen and water screen. So, irradiation device has flat cylindrical inside which contacts with Si ingot. This design model have some adventages. First, it prevent a ingot from eccentricity. Second, it prevent a demage from worn down by plate spring. And third, it is easy to make an irradiation device.

In order to verifying the validity of this design concept, we calculated the $Si^{30}(n,\gamma)Si^{31}$ reaction rate using MCNP code. And checked flatness of distribution of reaction rate. To find the flatness of distribution, axially, Si ingot is divided into 30 plates, and radially devided in 5 regions. The simulation is used 100 million history, and then, fractional standard deviation (fsd) is less than 0.5%.

2.3 Calculation Result

Fig. 3 shows the $Si^{30}(n,\gamma)Si^{31}$ reaction rate distribution of axial direction. We compared the reaction rates of 30 axial regions with the average value of those and calculated the axial flatness. The gap of maximum and minimum value is 1.42%. Therefore, it shows a good flatness within a ±1.0%.

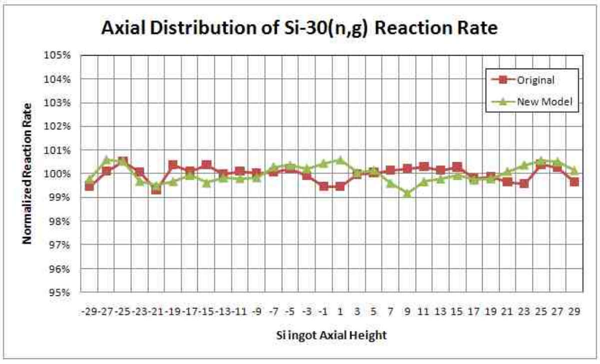

Fig. 3. Axial $Si^{30}(n,\gamma)Si^{31}$ reaction rate distribution

Fig. 4 shows the $Si^{30}(n,\gamma)Si^{31}$ reaction rate distribution of radial direction. We compared the reaction rates of 5 radial regions with the average value of those and calculated the radial flatness. The difference of maximum and minimum value is 1.99%. It shows a good flatness within a ±1.5%.

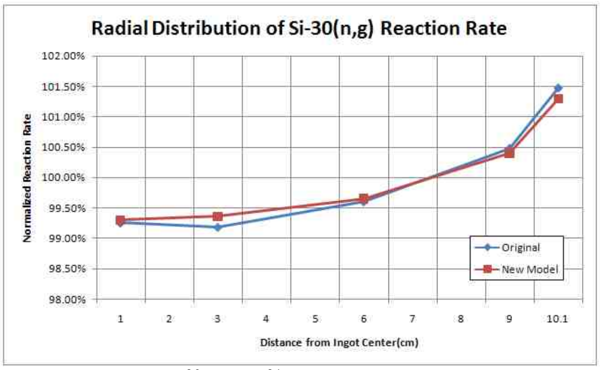

Fig. 4. Radial $Si^{30}(n,\gamma)Si^{31}$ reaction rate distribution

3. Conclusions

HANARO has been providing the commercial NTD service for 8-inch silicon ingot in the NTD1 hole since 2010. But, it's mechanical structure has some disadvantages such as eccentricity of Si ingot.

We introduced the new design concept of 8-inch NTD1 neutron screen for improving NTD1 irradiation device of HANARO. In order to verifying the validity of this design concept, the $Si^{30}(n,\gamma)Si^{31}$ reaction rate was calculated by MCNP code. The axial and radial distribution of reaction rate is estimated to be within ±1.0%, ±1.5%. It shows a good flatness of axial and radial direction. Consequently, if this design concept were adopted, new 8-inch NTD device would have good mechanical advantages for the commercial NTD service.

REFERENCES

[1] H.S. Kim, et al., "Design of Neutron Screen for 8″ NTD Irradiation in HANARO," Proc. of 2005 KNS Autumn Meeting, KNS (2005)