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Dedicated facility for mass-producing of doped Silicon

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Nowadays, the use of electric vehicles such as hybrid cars and electric trains is increasing rapidly. Each such vehicle requires a considerable amount of semiconductor devices, suggesting an ever-growing demand for such devices in the near future. Thus, the mass production of the semiconductor material is becoming a very important issue for many manufacturers. There are several methods for mass production, but Neutron Transmutation Doping of Silicon (NTD-Si) is the most promising method for the production of silicon based semiconductor.

Rapid increase in demand of hybrid cars is expected due to the high cost of fuel and environmental concerns. A recent survey made by Korean Atomic Energy Research Institute (KAERI) indicated that 50 million hybrid electric vehicles would be produced, and almost 1000 tons of NTD-Si would be needed in 2030.

At present, the worldwide capacity of the NTD-Si facilities is estimated to be 150-180 tons per annum. This capacity cannot be increased drastically because most research reactors with NTD facilities were constructed many years ago and they have little potential for expansion; in addition, number of research reactors to be constructed in the future is few. Another important issue is that the present research reactors are not NTD-dedicated facilities, and thus a stable and adequate supply is not expected. If the hybrid electric vehicles increase according to the current forecast, the existing research reactors cannot supply future demand. As such, a new doping facility with a large irradiation capacity for NTD-Si may need to be constructed to ensure an adequate supply of doped silicon.

Two design concepts were proposed. The neutronic and thermal hydraulic analyses were performed to obtain the optimum core composition, operating period, necessary condition for uniform doping and the reactor production rate.

First one was a design concept of a small reactor for large-diameter NTD-Si using full-length conventional PWR fuel assemblies. The idea was to use commercially available conventional PWR fuel (fabricated for power reactors) directly without any modification. Estimated production rate varies between 111 tons/year and 140 tons/year for 50 Ωcm target resistivity depending on the control rod positions.

Second one was a design concept of a small reactor for large-diameter NTD-Si using short PWR fuel assemblies. Estimated production rate varies between 48 tons/year and 70 tons/year for 50 Ωcm.

The first concept has a very good performance, for instance, a long operating period (about 18 years) and a large production rate, but the size of the core could become big which could lead a large construction cost (initial investment). On the other hand, the reactor concept using short PWR fuel assemblies might require a less construction cost due to the smaller core, and the production rate was not that bad, but the operating period was shorter (about 3 years) than first concept. This concept with short assemblies may be attractive if the shorter PWR assemblies can be fabricated without major difficulties in existing fuel manufacturers, needless to say that they are technically capable to produce such assemblies.

Another important point is that fuel supply for these concepts is more reliable and fuel management is easier because PWR fuel fabrication and processing facilities well established compared to the research reactor.

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