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Results and Analysis of NTD Operation in HANARO

Ki-Doo Kang *, Sang-Jun Park and Myong-Seop Kim
Korea Atomic Energy Research Institute
1045 Daedeok-daero, Yuseong, Daejeon, 305-353, Korea,
**Corresponding author: dooki@kaeri.re.kr*

1. Introduction

Recently, a worldwide attention to the green energy technologies is higher than ever for solving the problems of energy starvation and global warming. Here, the power devices such as IGBT, IGCT and GTO became one contributing factor to the issue and demand of such power devices is rapidly increasing in every area of the industry.

The NTD (Neutron Transmutation Doping) wafers are common in the high power device market, and they are known a as powerful solution to give very high performance. Other techniques are also available, but their applications are very restricted because of high cost, low productivity, or limitation of applicable operating voltage

Now NTD is in the spotlight as a valuable topic in the commercial utilization of the research reactors. Since 2002, we have provided the best quality NTD silicon (NTD-Si) to the world market using HANARO reactor [1, 2] and also have increased the production capacity to keep up with the rapidly changing market situation.

2. NTD Operation in HANARO

2.1 NTD-Si market situation

It is difficult to evaluate and forecast exactly the NTD-Si market because the market strongly depends on the situation of the research reactors in spite that demand for power devices will be accelerated further. If focusing on the power modules such as IGBT and thyristors, it is forecasted that the market growth will be mainly leaded by the industries of ships, wind turbine, grid power and rail traction at an average rate of 7% annually until 2020. According to our own investigation, however the car industry has a great potential to the power module market. The world production of hybrid electric vehicles (HEV) is predicted to go up 10 times in 2020 and 50 times in 2030, and the power modules will be needed at the same rate [3].

As of 2009, the world NTD-Si market size is estimated at around 150 ~ 200 tons per year but it is thought to be nearly the maximum production capacity. In order to meet increasing demand and to meet asking for more powerful power devices, other substitute materials such as SiC or epitaxy technology are have been developed. Comparing to silicon, SiC has outstanding material properties of wider band-gap, higher breakdown voltage, faster drift speed of carrier and better heat conductivity. On the contrary, they also have limitations such as product and cost. Therefore it is not possibly realistic to expect that they will eventually replace all silicon based devices, instead there may be a clearly differentiated market sharing between NTD-Si and SiC or other substrates

2.2 Production of NTD-Si

HANARO has two vertical irradiation holes for NTD of the silicon crystals. We started with 5 inch NTD-Si from 2002 and added 6 inch from 2005. And then we expanded the production capacity by including 8 inch from 2008. Fig.1 shows the annual records of NTD-Si production since the first commercial service in 2002. NTD business of HANARO has been grown steadily all the while and more rapid growth is expected from this year due to the recovery of HANARO operation time. During the last several years, HANARO was operated at a rate of 50 ~ 60% of its nominal operating capacity in order to install the new facilities.

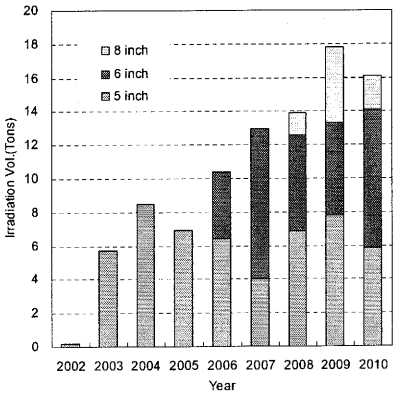

Fig. 1 Annual records of NTD-Si production

We produced a total of 18 tons of NTD-Si including 4 tons of 8-inch in 2009. In 2010 we accomplished around 16 tons by the 2nd quarter of 2010 and we are expecting that the total production in 2010 will be over 30 tons.

At present, 5 and 6 inch NTD-Si wafers are the main items of the market. The 6 inch wafer is likely to grow continuously and the 8 inch wafer is becoming a new marketable item. Especially the 8 inch wafer is soaring with the commercialization of HEVs. Although the production of 8 inch floating-zone (FZ) silicon crystal is just in its infancy yet, it will take a big portion of the market soon. HANARO can afford to produce 8 inch

more than 20 tons per year without sacrificing the current volume of 5 and 6 inches.

2.3 Variation of target resistivity

There was a remarkable change in resistivity of the NTD-Si as shown in the Fig. 2. A line graph in the figure is represents the average resistivity estimated based on the number of irradiation. Before 2006, most target resistivity values were less than 50 ohm-cm, but after then the demand for the higher resistivity is increased. This is connected with a new customer in 2007 that used to order higher resistivity mainly. However, it is also connected with the increased demand from the grid power industry. It requires the power devices for the supply and transmission of electric power, which are operating with higher voltage or current. Especially the demands of 300 ~ 400 ohm-cm is increasing faster. The maximum resistivity is around 1,000 ohm-cm. The demands for 8 inch come from Japanese customers. They are mainly used for the hybrid cars and their required resistivity is around 50 ohm-cm.

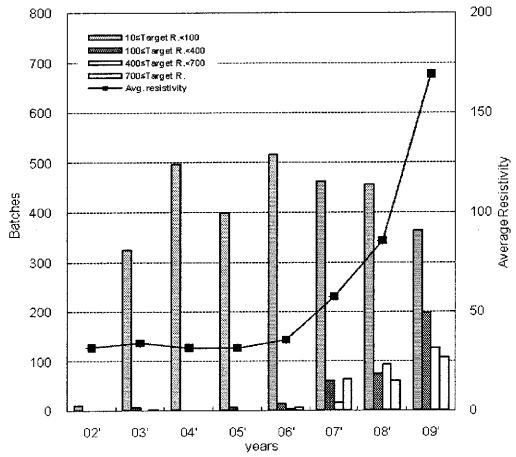

Fig. 2 Annual changes of requested resistivity of NTD-Si

3. Conclusions

The current use of NTD-Si is expected only 150 ~ 200 tons per year. This is because there are not many research reactors capable of mass production of NTD-Si and therefore the market size is determined by the supply capacity. The NTD is the only way to produce semiconductor material for high power devices in a large scale. New technologies like SiC or epitaxy are being developed but NTD is much more competitive for now and for a while considering the production cost and the productivity.

HANARO has the highest productivity of NTD-Si in the world. We have increased the production capacity according to the market condition and now providing more than 15% of the total worldwide demand. A total 18 tons was produced in 2009 and more than 30 tons is expected in 2010. The market trend is changing to the higher target resistivity reflecting the growth of grid power industry and the demand of 8 inch NTD-Si is gradually increasing along with the popularization of HEV. We are planning to produce maximum 50 tons per year when the mass production of 8 inch FZ crystal is possible [4]. An additional reactor which is capable of more productivity is planning.

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