NEUTRON TRANSMUTATION DOPING OF SILICON WITH PHOSPORUS

A. W. Carbonari, J. R. Sebastião, W. Pendl Jr., R. N. Saxena and M.S. Dias

Comissão Nacional de Energia Nuclear
CNEN-SP
05499, São Paulo, Brasil

Nuclear transformation of silicon into phosphorus nuclei following thermal neutron capture reaction

$$^{30}Si(n,\gamma)^{31}Si \longrightarrow ^{31}P + \beta^-$$

has been developed into a very efficient technique for doping monocrystaline silicon with phosphorus. Because of the superior doping homogeneity (small spreading resistivity) and doping accuracy (resistivity very close to the target value) which results from the NTD process, a far better semiconductor material is obtained, for a number of devices applications, than what can be obtained through a conventional chemical doping.

An irradiation rig has been constructed and installed at the 2 MW pool-type IEA-R1 research reactor for doping single crystals of silicon up to 4 inches in diameter. Very carreful and extensive measurements of vertical neutron flux profile at the irradiation position have been carried out. The irradiation is controlled by two silver self-powered neutron detectors placed close to the crystal position. The final neutron dose is measured by cobalt monitors which are irradiated together with the silicon crystal.

Test experiments indicated the possibility of irradiating up to 50 cm long crystals (two pieces of 25 cm each) resulting in the doping uniformity better than 10 percent (axial) and 2 percent (radial), for a 4 inches diameter crystal. Target resistivity values of the order of 32-35 Ω.cm have been reached for float zone (FZ) high resistivity silicon crystals irradiated through a period of approximately 28-30 hours (neutron dose ~ 8.3 x $10^{17} n/cm^2$). Commercial production of NTD silicon is being initiated with a modest irradiation capacity of approximatelly 400 kg per year.

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