

## Early 1970s

### Control of threshold levels by ion implantation

#### ~ Process Technology ~

In ion implantation equipment, elements such as group III boron (B), group V phosphorus (P), arsenic (As) are ionized, accelerated by high voltage, and injected into Si. The amount of impurities injected is given by the time integral of the ion beam current. Since the injected ions are stopped by repeated collision scattering with Si atoms, the implantation depth depends on the ion mass and acceleration energy. In the medium current ion implanter, the ion beam current is in the order of micro-amperes and is used for implanting impurities of relatively low concentration. Since ions can be accelerated with energies in the wide range of several keV to several hundred keV, it is applied to various processes in the manufacturing of semiconductor devices.

In the 1970s, threshold voltage control of transistors by ion implantation into the channel portions of the MOS transistors, and prevention of inversion of the isolation regions by implantation into the isolation regions were applied (in the case of NMOS at that time, thick oxide film was formed after boron implantation).

Going back into the history of ion implanters, it goes back to particle accelerators in the 1950s. In 1954, W. Shockley acquired a patent to implant ions into semiconductors, and in 1969, K. G. Aubuchon of Hughes Aircraft announced a method to control the threshold voltage by ion implantation into the MOS channel region. At that time, there were Ion Physics Corp., High Voltage Engineering, DANFYSIC, Accelerate Inc., etc. as the manufacturers of ion implantation equipment. In 1971, many ion implantation equipment manufacturers such as Lintott, Extrion, ORTEC were established, but the M&A of these manufactures continued after that until late 1970, such as merger of Ion Physics Corp. with High Voltage Engineering, ORTEC with GCA, acquisition of Extrion by Varian. In Japan, Nissin High Voltage began production in 1974, Japan Aerospace Technology started domestic production jointly with Extrion, and a joint venture between Tokyo Electron and Varian was established in 1982.