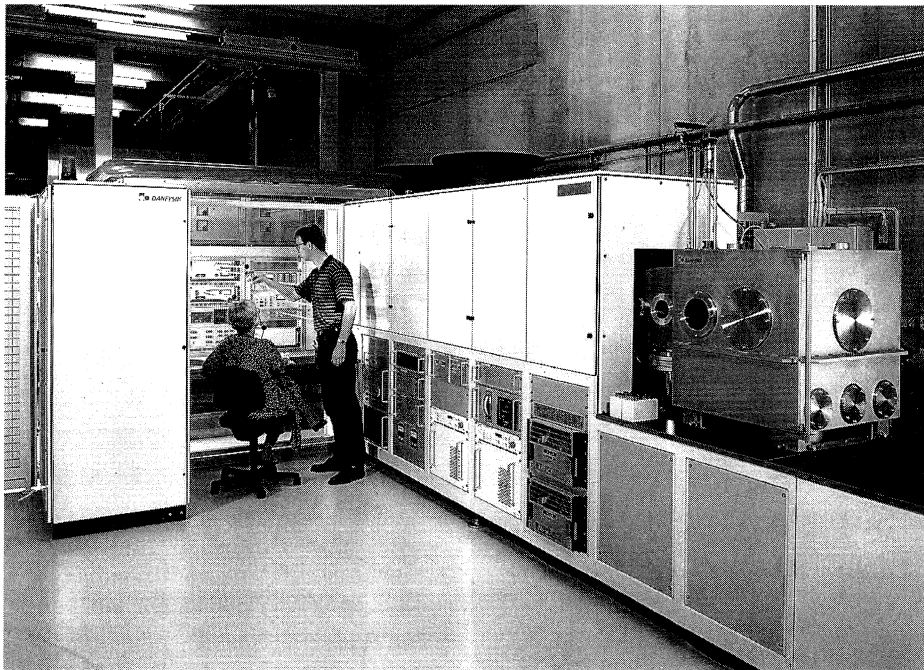


A high-current industrial ion implantation system used for treating metal surfaces.
(Photo Danfysik, Jyllinge, Denmark)



Most industrial ion implantation processing is handled by specialist companies and the demand is increasing. It is a challenge for the implanter manufacturers to satisfy higher demands for efficiency, reliability and reduced cost.

From Bjarne Roger Nielsen, Danfysik, Jyllinge, Denmark.

Ion implantation for semiconductors

Over the past two decades, thousands of particle accelerators have been used to implant foreign atoms like boron, phosphorus and arsenic into silicon crystal wafers to produce special embedded layers for manufacturing semiconductor devices.

Depending on the device required, the atomic species, the depth of implant and doping levels are the main parameters for the implantation

process; the selection and parameter control is totally automated.

The depth of the implant, usually less than 1 micron, is determined by the ion energy, which can be varied between 2 and 600 keV. The ion beam is extracted from a Freeman or Bernas type ion source and accelerated to 60 keV before mass analysis. For higher beam energies post-acceleration is applied up to 200 keV and even higher energies can be achieved by mass selecting multiply-charged ions, but with a corresponding reduction in beam output.

Depending on the device to be manufactured, doping levels can range from 10^{10} to 10^{15} atoms/cm² and are controlled by implanter beam currents in the range up to 30mA; continuous process monitoring ensures uniformity across the wafer of better than 1%.

As semiconductor devices get smaller, additional sophistication is required in the design of the implanter. The silicon wafers charge electrically during implantation and

this charge must be dissipated continuously to reduce the electrical stress in the device and avoid destructive electrical breakdown. Electron flood guns produce low energy electrons (below 10 electronvolts) to neutralize positive charge buildup and implanter design must ensure minimum contamination by other isotopic species and ensure low internal sputter rates.

The pace of technology in the semiconductor industry is such that implanters are being built now for 256 Megabit circuits but which are only likely to be widely available five years from now. Several specialist companies manufacture implanter systems, each costing around US\$5 million, depending on the configuration and remote handling options. Current implanter capacities are around 60 wafers/hr, each wafer being 150mm in diameter with a typical doping level of 3×10^{15} cm⁻².

From T. Grey-Morgan, Amersham International, UK

Contraband detection

Inspecting incoming cargo for drugs, explosives and other contraband would quickly overwhelm inspection agencies even if a small percentage of the cargoes were manually searched. Now a new accelerator-based inspection system using pulsed fast neutron analysis (PFNA) allows automated inspection of loaded cargo containers and trucks.

A collimated pulsed beam of fast neutrons, scanned over the side of a cargo container as it passes, excites the nuclei of common elements in