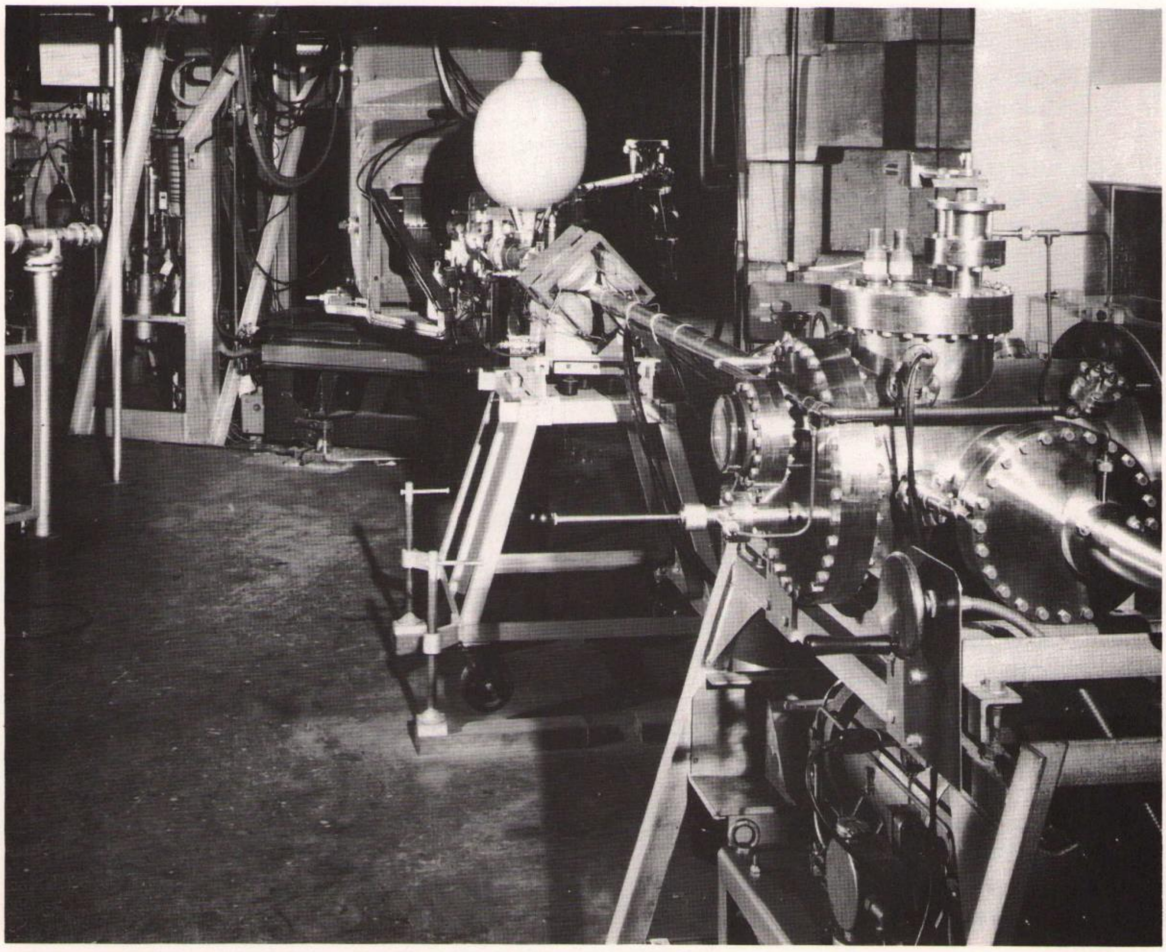
Cockcroft-Walton ion implantation and ion bombardment facility

The Cockcroft-Walton facility comprises a 450 kV Philips voltage-multiplier set, a versatile ion source capable of producing ions of virtually any element, and a 90° mass-analysing magnet. This magnet is mounted on a rotatable turntable, and can inject a horizontal ion beam into any one of six beam lines which are equipped for different kinds of experiment.

Target facilities are provided suitable for ion implantation, ion bombardment, ion transmission experiments, Rutherford back-scattering and fast neutron production. The ion implantation equipment is extensively used by industrial, university and government laboratory teams. Ion energies (singly-charged) lie in the range 80 to 450 keV. Varied conditions of target temperature and orientation can be provided, and turbo-molecular plus ion pumps ensure clean vacuum conditions. For fast neutron work, a heavily-shielded concrete cell is available.



Some uses of the facility

Ion Implantation

The introduction of foreign atoms into the surface of a material by means of an accelerated ion beam is an increasingly important and highly controllable technique in surface materials technology.

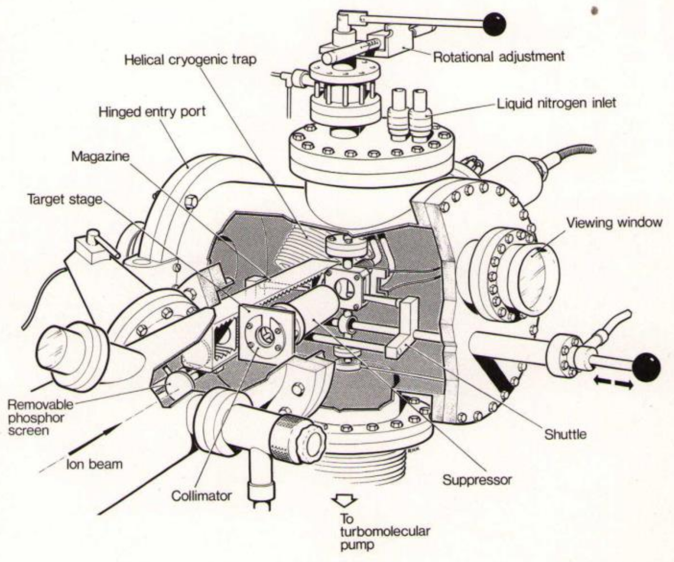
The Cockcroft-Walton is one of a number of accelerators adapted at Harwell for ion implantation, the others being the electromagnetic isotope separators, a 130 keV heavy ion accelerator, and the 6 MV Van de Graaff. The Cockcroft-Walton is most often used when relatively penetrating ions, between 150 and 450 keV, are required.

In the **Semiconductors,** ion implantation is now employed by all the major device-producing companies throughout the world. The advantages of the method lie in its good uniformity and reproducibility, the fact that it does not require such high temperature processing as diffusion, is compatible with conventional masking, allows flexible profile control and can be monitored throughout.

In **Metals,** ion implantation is being used as a means of modifying surface composition for conveying corrosion resistance, wear resistance, hardness, low friction, and modified electrochemical behaviour. It affords a powerful tool for corrosion science, particularly in conjunction with ion scattering techniques (described below) for surface examination. There is scope also for the study of improved means of bonding metals.

In **Optical Materials,** ion implantation has been shown to give rise to useful refractive index modification. **Superconductors** undergo changes in critical field as a result of ion implantation, and the composition of thin-film type II superconductors can be modified. **Oxide** films can be doped by ion implantation, and their electrical properties have been altered. All these effects, now established experimentally, have practical possibilities in such areas as optical waveguides, Josephson junctions, anodic capacitors and cold-cathode emitter arrays. The use of the Cockcroft-Walton can allow these to be explored.

Specimen sizes up to 31 mm diameter can be accommodated in standard target holders and uniform doping achieved by electrostatically scanning the beam spot. As many as 36 specimens can be loaded into the implantation chamber simultaneously. Provision is made for heating or cooling the target stage and orientation of crystals ± 8° to the beam direction. The normal operating pressure in the target chamber is 10^{-7} Torr.



Ion implantation chamber

Ion Bombardment

Here the emphasis is upon the effects of the kinetic energy of the ions on the structure of the material. Radiation damage can be studied, for example in crystals or crystalline devices. Irradiation will enhance diffusion processes in potentially useful ways. The X-rays produced as a result of ion bombardment can be used to determine the composition of a surface, often with great sensitivity. Ion backscattering will also provide a quantitative means of analysing surface composition. The Cockcroft-Walton allows bombardments under widely varied conditions, and with the minimum risk of hydrocarbon contamination.

Neutron and Gamma Irradiations

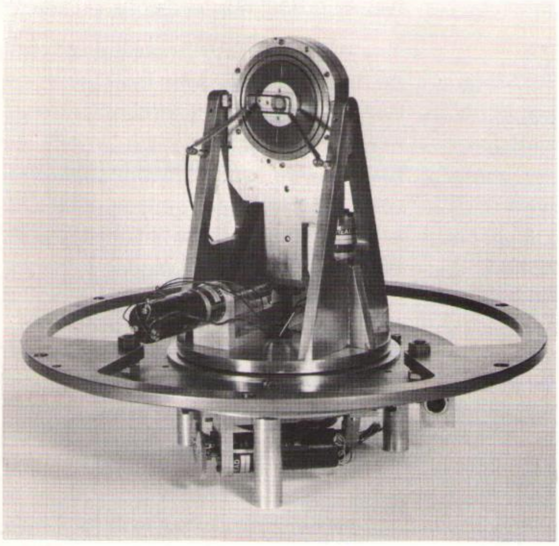
The high intensity proton and deuteron beams from the Cockcroft-Walton provide a means of generating high fluxes of neutrons and gamma-rays for irradiations which can be carried out in complete safety within a heavily-shielded concrete cell, fitted with a transparent window. Up to 10^{11} neutrons/ second can be produced from cooled tritium-loaded targets. The facility is often used for biological or botanical studies, or measurements of shielding.

Ion	Current μa	Ion	Current μa	Ion	Current μa
H^1	50	V^{51}	0·5	Sn^{120}	5
He^4	5	Cr^{52}	2	Sb^{121}	1
Li^7	2	Mn^{55}	1	Te^{130}	0·2
B^{11}	1	Fe^{56}	5	Xe^{132}	5
C^{12}	2	Ni^{58}	1·5	Cs^{133}	3
N^{14}	6	Cu^{63}	4	Ba^{138}	4
O^{16}	6	Zn^{64}	1	La^{139}	2
F^{19}	1	Ga^{69}	0·6	Ce^{140}	2
Ne^{20}	15	Ge^{74}	0·6	Nd^{142}	0·2
Na^{23}	1	As^{75}	5	Sm^{152}	0·5
Mg^{24}	2	Se^{80}	1	Eu^{153}	3
Al^{27}	3	Kr^{84}	10	Gd^{158}	0·5
Si^{28}	4	Y^{89}	3	Tb^{159}	3
P^{31}	1	Zr^{90}	0·2	Ho^{165}	0·5
S^{32}	2	Nb^{93}	0·5	Er^{166}	0·4
Cl^{35}	10	Mo^{98}	0·5	Tm^{169}	2
Ar^{40}	50	Ag^{107}	2	Au^{197}	1
Ca^{40}	2	Cd^{112}	2	Hg^{202}	0·2
Ti^{48}	2	In^{115}	0·5	Pb^{208}	0·5
				Bi^{209}	1

Typical target beam currents for singly charged ions are shown in the table above

Above mass 106 the upper energy limit for beams of singly charged ions is limited by the saturation field value of the 90° bending magnet and varies as $450\left(\frac{106}{M}\right)$ keV

However useful beam currents of multiply charged ions are often available. The upper energy limit for doubly charged ions up to mass 212 is 900 keV. The use of molecular beams, e.g. H_2, N_2, O_2, Cl_2 will reduce the low energy limit to 40 keV.



Services available

We aim to enable a client to establish the technical feasibility of an ion implantation process and its compatibility with his other processing stages, before he needs to commit himself to heavy capital expenditure. To do this we offer:

Advice on the suitability of ion implantation for a given material and process.

Experimental or pilot scale implantations or bombardments.

Lease of machine time to clients who wish to carry out their own implantations.

Assistance with design of clients own implantation facilities.

- No charge is made for initial exploratory discussions.
- Prices and terms are negotiated with the client before any financial commitment is undertaken.
- Our experience in protecting information ensures that the interests of our clients can be dealt with in strict confidence.

For further information on any of the topics described in this leaflet, or on related services, write to:

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Bldg. H8
AERE Harwell Oxfordshire
or Telephone Abingdon (0235) 24141
Extension 2497

Related services include applications of other types of accelerated particle beams, described in the brochure 'Accelerator Services', obtainable from Miss J. Lincoln at the above address.

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