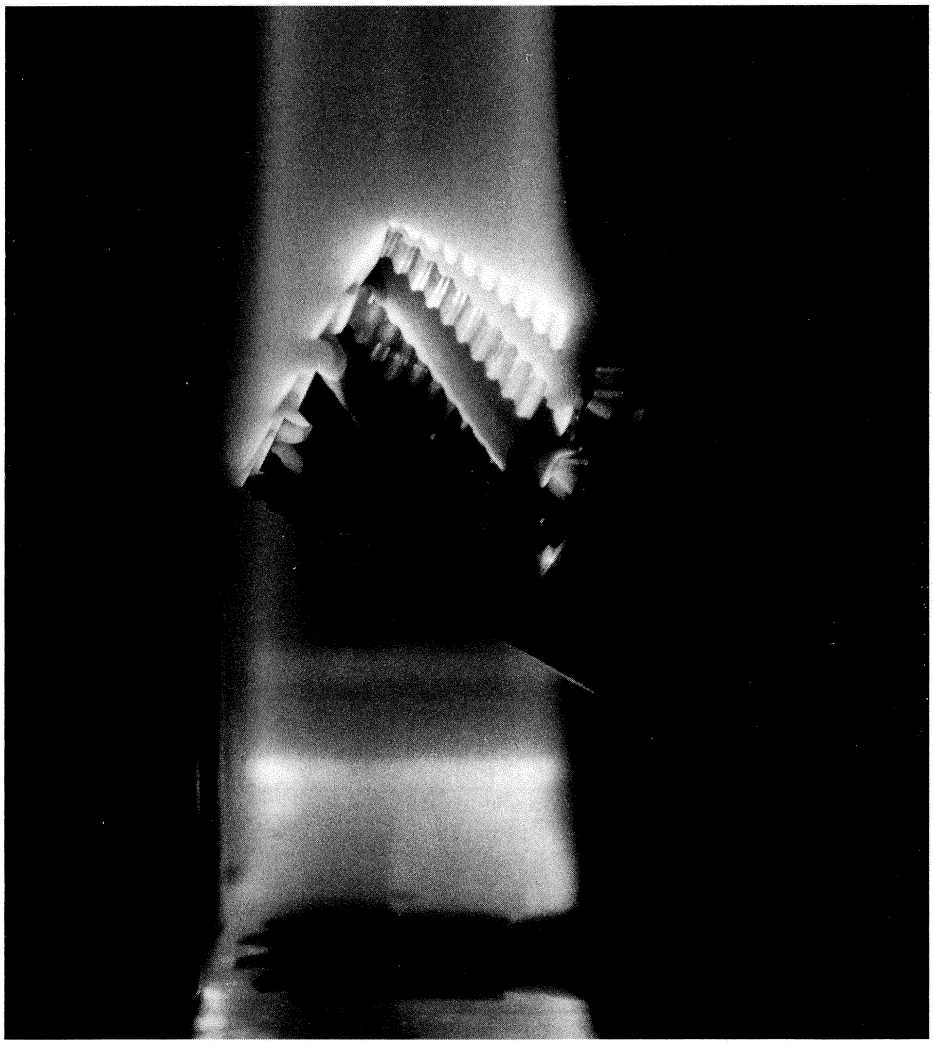
Ion beams bring important benefits to material processing

(Photo Leybold AG)



APPLICATIONS Accelerators for new materials

Ion beams bring important benefits to material processing, and the Seventh International Conference on Ion Beam Modification of Materials (IBMM 90), held in Knoxville, Tennessee, in September showed the promising progress being made.

The biannual IBMM conferences were originally created through a unification of international conferences on ion implantation in semiconductors and ion implantation in metals. These two materials are still important targets for ion beam treatment, but today's most important results come from insulators.

Today's ion beam modification techniques use mechanisms other than strict ion implantation. From the use of heavy ion beams of 100 keV and a few microamps for standard implantations in semiconductors twenty years ago, the use of accelerators for materials modification has come a long way. Multi-MeV beams are being used for creating buried oxide and nitride layers in semiconductors with an eye on creating three-dimensional integrated-circuit structures. Beams of many milliamps are being used for surface treatment of large and complicated stainless-steel machine parts aiming at better corrosion, friction and wear resistance.

The most exciting results in semiconductors presented at the conference came from attempts to push miniaturization, using extremely fine-focused ion beams, obtained from a liquid-metal ion source. A.J. Steckl (Cincinatti) told about focal spots of 600 nm with beam densities of the order of a milliamp per sq mm. As well as being used for mask repair in LSI circuit fabrication, these beams may be used more profitably for producing miniature optical structures in III-V semiconductor sandwiches like GaAs/GaAlAs.

M.Bode (AT&T Bell Laboratories) described perhaps the ultimate miniaturization – imaging the tracks of single ions passing through a multilayer GaAs/AlAs sandwich. The chemical changes caused by the passage may be imaged with a lateral resolution of one interatomic distance or 0.2 nm – perhaps also the ultimate resolution for vertex detectors!

The electrochemical processes induced by the radiation damage in the multilayer stack appear at one type of surface only. As Bode put it, it is like firing a bullet through a telephone book, and opening the book to find holes only on the odd- and not the even-numbered pages!

III-V semiconductors are generally not well suited for ion implantation because any accompanying damage to the crystal lattice may not be entirely removed by a rapid thermal anneal and give a group III atom on a group V site or vice ver-

sa. Such mixups are not possible in silicon, which may be why silicon appears to be coming back strongly as the favourite semiconductor for treatment by ion implantation. The creation of buried nitride or oxide layers for SIMOX structures was discussed by Peter Hemment (Guildford).

The absolute highlight of the conference was the presentation by Chris Buchal (Jülich) of doping and damage patterning of electro-optical materials like potassium- or lithium niobate. Although describing some of his perspectives as 'speculative' and 'science fiction', he nevertheless managed to persuade the audience that rare-earth implantations in these materials could provide miniature integrated optical amplifiers, lasers, mixers and switches. These ideas will surely be important for both communication techniques and computer development in the coming decade.

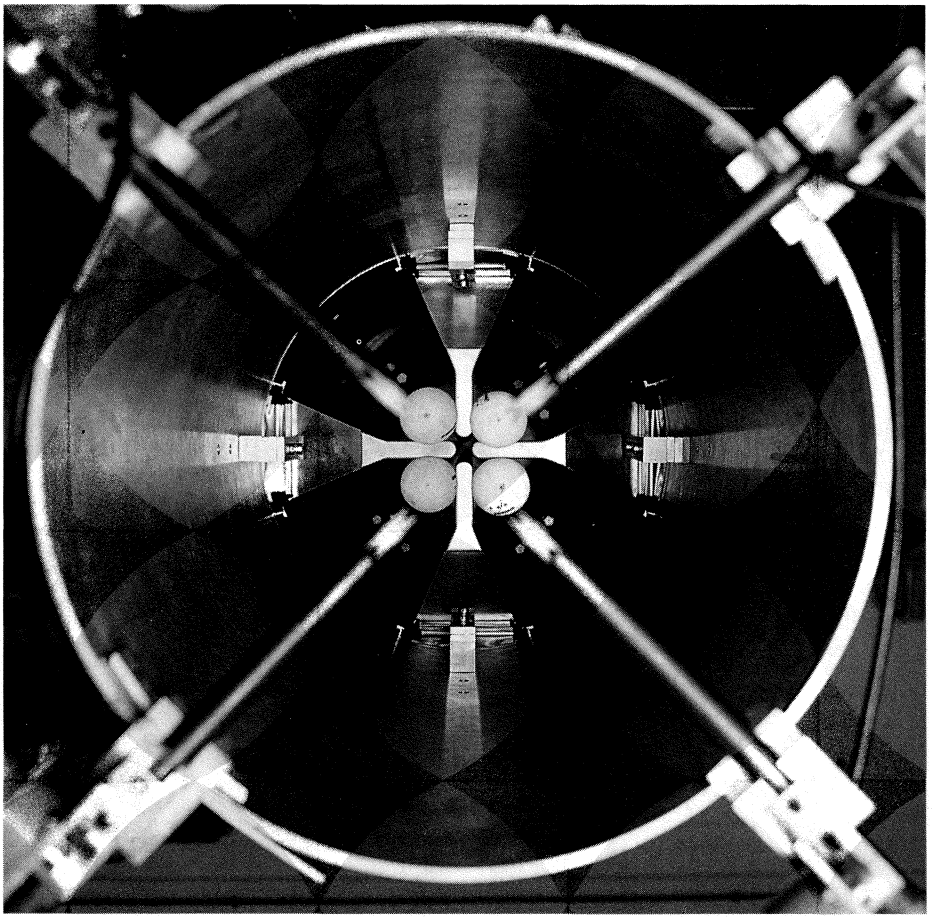
For a number of years it has been known that many vacuum-deposited films can be improved by bombardment with eV ions during deposition, presumably due to increased mobility of the deposited atoms which helps anneal out defects.

Another claim is that bombardment with large clusters (hundreds of atoms) further improves the quality of deposited films. Walther Brown (AT&T Bell Laboratories) showed that the commonly used source for these beams does not produce any large clusters and that the undeniably beneficial effects must come from single atom bombardment or bombardment with small clusters. This may be quite fortunate as Bob Averback (Urbana) showed in a series of very illuminating computer simulations that bombardment with large clusters does not promote the formation of atomically flat surfaces, giving instead meteor-like craters.

Energetic beams also play a role in the creation of high-temperature superconductors with improved current carrying capacity. Wei-Kan Chu (Texas Center for Superconductivity) described radiation effects induced by ion, neutron, electron, x-ray and gamma-ray beams. For the moment only neutron irradiation appears to give a beneficial effect. With an eye on future applications of these materials for large accelerator magnets, it is interesting to note that the extreme radiation sensitivity originally reported for these materials is found only in poor-quality samples.

(The proceedings of the conference will appear in the May 1991 issue of Nuclear Instruments and Methods B.)

From H.H.Andersen, Copenhagen



The radiofrequency quadrupole (RFQ), fast becoming the standard compact linear accelerator.

(Photo CERN 46.11.89)

WORKSHOP Linac90

In 1960 the first linear accelerator (linac) conference was organized at Brookhaven by John Blewett. In the few years following, linear accelerator energies jumped from 50 MeV (at Brookhaven and CERN) to 2 GeV at Stanford. With the realization that, at least for electrons, circular accelerators have reached their practical limits, linacs are once more in the spotlight.

At this year's linac conference (the 15th), held in Albuquerque, New Mexico, present-day machines described covered the spectrum from industrial and medical x-ray linacs to Stanford's SLC 50 GeV linear collider, while on the drawing boards are linacs pushing all frontiers of operation including energies to 1 TeV for a vast variety of applications in and outside of the research laboratory.

One of the most popular topics at the meeting, with about 25 papers and posters, was the radiofrequency quadrupole (RFQ), a small linear accelerator suitable for low-velocity ion beams (June 1987,