Abstract: Use of ion beams in space

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Ion beams of MeV energy are in routine use as depth microscopes to determine composition and impurity profiles with depth resolutions of 100–300 Å over near-surface regions. Backscattering spectrometry with He ions and proton-induced x-rays are simple to implement. These techniques have been used in studies of thin-film reactions, solid-phase epitaxy, metallurgy of integrated circuits and solar cells, oxidation and corrosion, and other near-surface phenomena. The Spacelab orbital environment provides the possibility of depositing contamination-free films on clean interfaces. Ion beam techniques for material analysis can then be used to evaluate thin-film interdiffusion, and compound formation in a contaminant-free ambient. In addition, the ion beam techniques would be available for rapid analysis of near-surface regions of other experiments, such as molecular-beam epitaxy.

The instrumentation-semiconductor nuclear-particle detectors and multichannel analyzer for such measurements are simple and were used in early Surveyor lunar analyses. The accelerator is based on the tandem accelerator principle pumped by the vacuum of space. It consists of a series of eight light equispaced titanium concentric spheres which are supported on a single insulating hollow column. The largest sphere which is at the potential of the spacecraft has a diameter of 200 cm. The smallest sphere has a diameter of 30 cm and is maintained at 1 MV potential. Voltage is generated between the largest sphere and the smallest sphere by using an inductively charged stapled belt to physically transfer charge. The belt system operates in vacuum within the confines of the hollow insulating column and needs only energy to supply bearing losses and the work done against the electrostatic forces. A series of small holes located collinear on the concentric spheres create a region of uniform electrostatic field which accelerate negative particles to 1 MeV at the terminal. Here a small gas canal is used for stripping electrons from the particles, causing them to change sign from negative to positive. These positive particles are repelled from the terminal back to ground to give He^{++} particles with energies up to 3 MeV and H^+ of 2 MeV. Two types of ion sources would be provided with this device. The first, a simple Penning source, would produce H^- beams for proton-induced x-ray measurement. A second lithium exchange source would provide He^- for backscatter measurements.

