ELECTRON MICROSCOPY 1968

Pre-Congress Abstracts
of papers presented at the
Fourth European Regional Conference
held in

ROME
September 1 - 7, 1968

Edited by
DARIA STEVE BOCCIARELLI

Vol. I

ROMA 1968
TIPOGRAFIA POLIGLOTTA VATICANA

AN ATOM PROBE FIELD ION MICROSCOPE

Erwin W. Müller, S. Brooks McLane, and John A. Panitz

Department of Physics, The Pennsylvania State University
University Park, Pa., U.S.A.

The ultimate microanalytical instrument would display the image of the specimen in atomic resolution and would then allow identification of the individual atoms by their chemical nature. Applicable to a limited type of specimens, the atom probe field ion microscope[1] can achieve just that. A new, more elaborate instrument has been constructed (Fig. 1) in which the field ion image of a metal tip is displayed on the screen, where it can be photographed (Figs. 2 and 3). Any atom spot of interest to the observer, such as an unusually bright spot or an atom at a particular lattice site, can be brought onto a fine probe hole in the center of the image screen by tilting the liquid hydrogen or liquid nitrogen cooled microscope head over a useable crystallographic angle of ±45°, employing a micrometrically controlled gimbal system. The selected atomic or molecular particle is then ripped off the tip by a pulse of a few hundred volts amplitude and travels through the probe hole and the one meter long drift tube, at one end of which it is detected by a 14 stage electron multiplier. Simultaneously with the start of the particle to be identified by its time-of-flight, the beam of a Tektronix storage oscilloscope begins to sweep at a rate of 1 cm/microsecond, and the time of arrival of the particle is recorded as a spike on the trace. The rise time of the pulse is a fraction of a nsec, and the pulse duration is chosen between 2 and 20 nsec. Besides multiple charged atomic ions of the tip metals, molecular ions are also found to represent oxides and nitrides when oxygen and nitrogen have been adsorbed on the specimen. A significant result of the initial experiments is the field evaporation of tungsten at 78°K in the form of W^{+++} and W^{++++}, with the [100] zone decoration producing triply charged metal ions only. With iridium at 78°K as well as at 21°K Ir^{++} and Ir^{+++} are to be found equally abundant, while the [110] zone decoration atoms come off triply charged. Among the many possible applications, the instrument's use in the physical metallurgy of impure metals and alloys seems particularly promising, allowing masspectrometrical identification of individual interstitials, atom species in segregations and precipitates, as well as revealing the degree of short and long range order.

1. E. W. Müller, J. A. Panitz, and S. B. McLane, Rev. Sci. Instr. 39, January 1968.

Supported by the National Science Foundation.

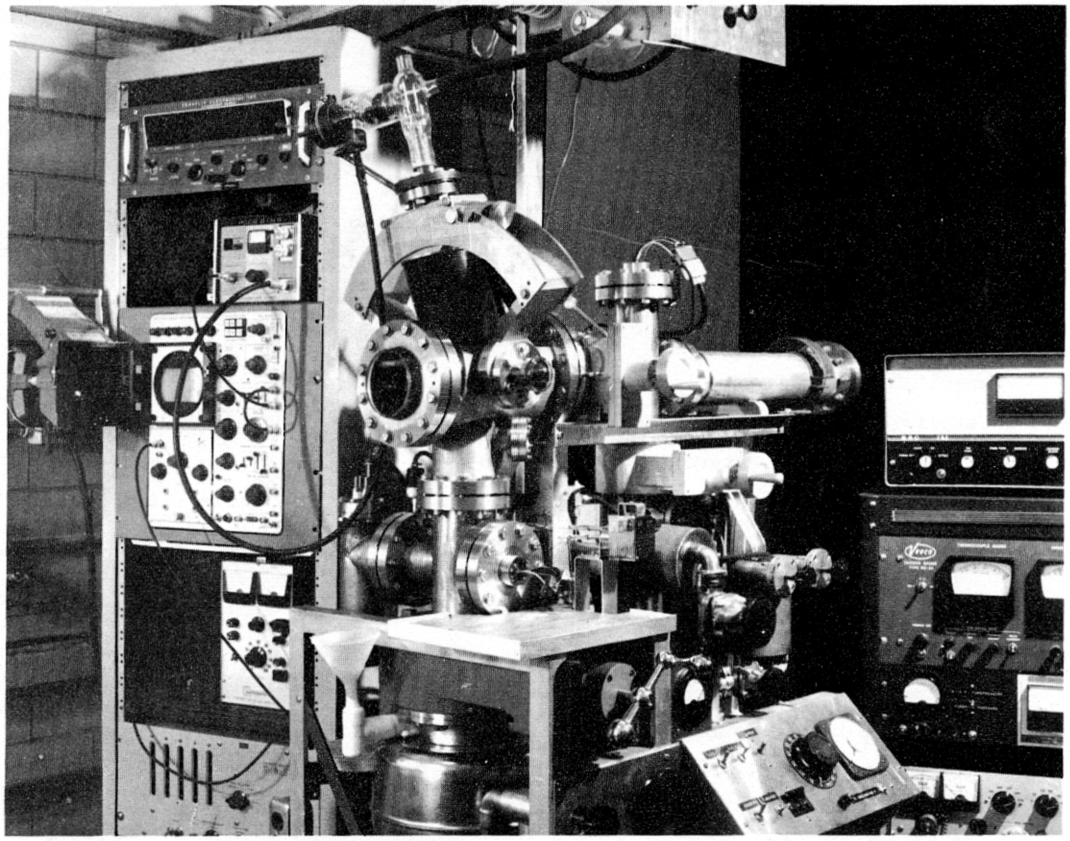
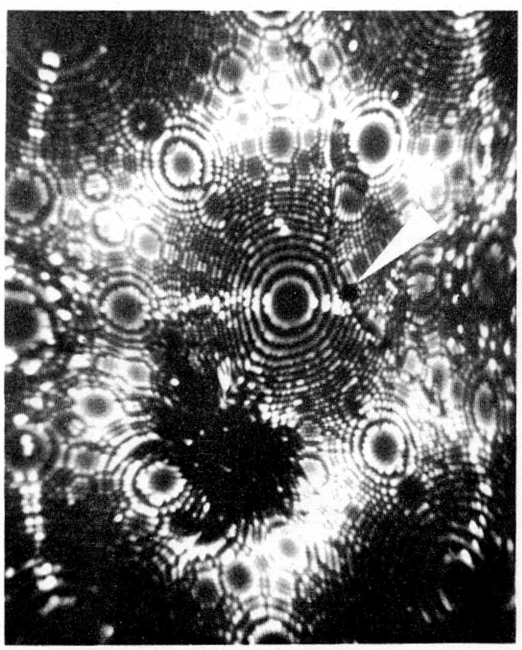


Fig. 1 Atom probe field ion microscope with 1 meter drift tube.



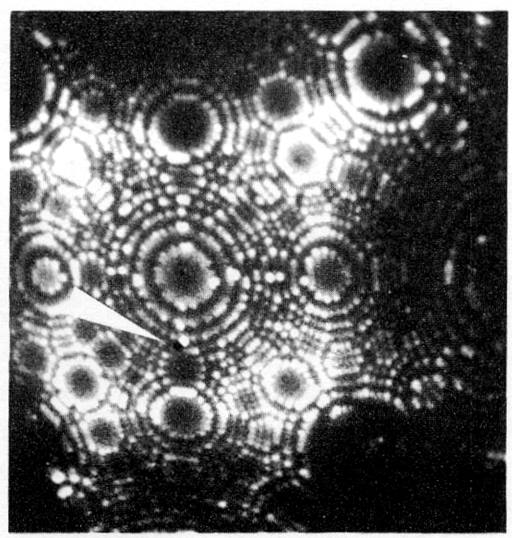


Fig 2, above. Probe hole beside a [110] zone decoration atom on iridium. (image intensifier, 1/50 sec exposure time.)

Fig 3, left. Probe hole center on an impurity atom at a grain boundary in tungsten specimen with inclusions, 78°K.