THE ADAPTATION OF A SYNCHROTRON RADIATION SOURCE FOR
SMALL AREA CHEMICAL ANALYSIS OF SURFACES AND THE MEASUREMENT OF
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Small area chemical analysis of the first 100 angstroms of
surfaces can be obtained directly from a limited number of ana-
lytical techniques. Few, other than secondary ion mass spectro-
metry and electron spectroscopy (PES or ESCA), also provide
oxidation state information as well. For non-conducting samples,
however, the PES/ESCA data are subject to a phenomenon known as
charge shifting. The photon interaction with the surface pro-
duces electron-hole pairs, and for non-conducting samples the
positive charges accumulate on the surface. This creates a
broadening in the observed electron distribution and a trans-
lation of the energy scale referenced to the spectrometer. We
have sought new techniques and approaches to: 1) reduce the area
sampled by the photon beam; 2) improve the analysis and assign-
ment of element and oxidation state on the surface; 3) compen-
sate for the sample charging; 4) measure the extent of sample
charging as a function of sample size and composition; and 5)
measure quantitatively the electron energy and distribution of
photoelectrons produced in a simulation of the photon irradiated
lunar surface. This is a progress report of our efforts in
adapting synchrotron radiation produced from an electron storage
ring as the photon source for these studies.

Synchrotron radiation produced from the 240 MeV electron
storage ring called Tantalus I (see Figure 1) was chosen as the
photon source because it and its new companion under construction
called Aladdin (see Figure 1) produce a continuum of vacuum
ultraviolet and soft x-irradiation with a greater range and
intensity than can be produced from laboratory sources. The
flux distribution will permit simulation of the solar photon
irradiation of the lunar surface. The source is produced in a
region of high vacuum and is positionally stable over long
periods of time. These features permit absolute flux calibra-
tion, the utilization of modulation techniques for curve decon-
volution, and freedom from source produced sample contamination.
Because the light is strongly polarized it is also possible to
utilize the angular distribution of the photoejected electrons
to provide additional information concerning structure and
crystal orientation. The experimental monochromators which have
been constructed to utilize synchrotron radiation also permit
the irradiation of small areas on the sample surface (see Figure
2). With an appropriate sample translator it is possible to
sample different areas on the surface and to scan across it.
THE ADAPTATION OF A SYNCHROTRON...

James W. Taylor, et al.

The complete apparatus to take advantage of the capabilities of the synchrotrons is nearly complete. Prototype and feasibility studies illustrating the reasoning behind each instrumental choice are in hand. The instrumental system is also designed to operate with VUV line radiation and x-ray sources. Of specific interest to Lunar Scientists should be a description of: a) the availability of the photon sources; b) the application of modulation techniques for enhancing energy level assignments; c) the techniques for providing absolute photon flux measurements (1); and d) the adaptation of Grunthaner's approach (2) for charge compensation and energy level reference which will work with any type of photon source. Specific applications to lunar samples include the question of dust charging (3), the chemical analysis of small areas, and the direct study of redox equilibria of selected ions.

References

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THE ADAPTATION OF A SYNCHROTRON ....

James W. Taylor, et al.

Figure 1
Flux in Photons/sec/mA/mrad in a 0.1% Bandwidth from (a) Tantalus I [available now] and (b) Aladdin [under construction]. Fluxes under typical conditions are with 100 mA and 40 mrad at Tantalus I.

Figure 2
Schematic of the Grazing Incidence Monochromator Designed for Use at a Storage Ring. [The designations M, S, and G refer to the entrance mirror, S the entrance slit, as a mirror, and the grating, respectively. Two positions of the elements are shown, one at a wavelength (A) and the other a zero order (0)].