Ion Beam Analysis: Beyond Traditional Applications

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As a well-established characterization method, Ion Beam Analysis (IBA) has found important applications in many research disciplines including materials science, art, archaeology, earth and environmental sciences. These traditional applications use particles generated from ion-target interactions exclusively for nondestructive target analysis such as stoichiometry, thickness, elemental depth profiling, trace impurity, and defect concentration etc. In this report, we demonstrate that the particles generated through ion-solid interactions during ion beam analysis may find other novel and important applications.

Our first application uses Rutherford backscattered and nuclear reaction produced proton particles to calibrate an energetic particle detector subsystem (called ZEP) of the Space and Atmospheric Burst Reporting System (SABRS). To simulate low radiation flux in the space environment, we have devised an experiment that uses a very thin (~50 nm) free-standing gold foil to scatter our Tandem’s proton beam into the ZEP subsystem. Direct backscattering from the very thin gold foil produces a chromatically narrow proton particles with tunable energies of 0.5 – 6.0 MeV and desired counting rates of <1 kHz. To extend the proton particle energy beyond the Tandem’s limit of 6 MeV, a nuclear reaction, $^2$H + $^3$He → p + $^4$He + 18.4 MeV, was used. This reaction allows us to obtain as high as 26 MeV proton particles from our 3 MV tandem accelerator. The ZEP subsystem calibration results are presented and discussed.

Our second application uses proton induced X-ray emissions to produce high energy characteristic X-rays for radiolysis research. In this experiment, a Yb foil was chosen for its relatively low gamma ray production cross sections. A 5.5 MeV proton beam energy was chosen to maximize Yb K-shell X-ray (50–60 keV) yields while minimizing neutron production. The foil thickness was chosen such that it is thick enough to completely stop the proton beam and to absorb L shell X-rays (7~10 keV) in the foil, but thin enough to minimize undesired K-shell X-ray self attenuations. These Yb K-shell X-rays subsequently impinge upon various targets for radiolysis studies. The X-ray radiolysis results from selected targets are presented and discussed.