Achieving the ultimate sensitivity in Accelerator Mass Spectrometry of high mass isotopes

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The VEGA AMS system at ANSTO, based on a 1MV tandem accelerator, was custom-designed to achieve the highest possible sensitivity for high mass isotopes [1]. It incorporates multiple medium-resolving power analysing elements: one magnetic element for the injected negative ions, followed by magnetic, electrostatic and second magnetic elements for positive ions after acceleration. This design, with mass and energy resolving powers in the range 500 to 1000, separates isotopes and suppresses backgrounds that may originate from a variety of ion species. The gas stripper in the high-voltage terminal is key both to system efficiency and to background suppression. Helium gas stripping is used, providing around 40% ion yield to the most abundant charge state (3+). The stripper pressure must be sufficient to break up all molecules while minimising the scattering angle of the ions as they undergo charge-changing collisions. Our recent work [1] has demonstrated that the need for production of negative molecular ions in AMS of actinides is not such a barrier to high efficiency: the VEGA sputter ion source can achieve greater than 1% efficiency for production of plutonium oxide negative ions and so overall sensitivity to a few hundred atoms in a sample is possible.

We are involved in a number of projects requiring high sensitivity and low backgrounds. Examples include (1) the detection of ^{244}Pu of extraterrestrial origin in deep oceanic ferromanganese crusts [2,3]; (2) radioecology of plutonium in the environment of former nuclear test sites [4,5]; (3) detection of nuclear signatures for nuclear safeguards and forensics; use of Pu in global fallout as a chrono-marker in environmental studies [6]; (4) measurement of platinum-group-element isotope ratios in meteorites; (5) evaluation of the radio-purity of materials for use in dark matter searches.

Each of these projects presents their own particular challenges. In some cases, sensitivity is limited by background from scattered ions of species other than the one of interest. In other situations, cross-contamination between samples, in the sample prep lab or ion source, limits sensitivity. Other projects or previous uses of laboratories may leave residual contamination. For stable and very long-lived species, such as PGEs and major uranium isotopes, the ubiquity of those species at low levels in almost all materials sets limits.

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