High Precision Uranium Isotope Ratio Measurments using Current Amplifiers with 10^{13} Ω Resistors

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Introduction

For many applications in geochemistry research isotope ratio measurements play a significant role. For instance, in geochronology isotope abundances of uranium and its daughter products thorium and lead are being used to determine the age and history of various samples of geological interest. For measuring the isotopic compositions of these elements by mass spectrometry, suitable isotope reference materials are needed in order to validate measurement procedures and to calibrate Faraday cup multi-collector and ion counting detector systems. JRC-Geel is a recognized provider for nuclear isotope reference materials to the nuclear industry and nuclear safeguards authorities, which are also being applied widely for geochemical applications.

Amplifiers with 10^{13} Ω Resistors

In order to reduce the signal-to-noise ratio, higher resistances can be utilized for Faraday cup current amplifiers. This is particularly important for measuring ion currents at the level of 10^{-16}–10^{-14} A which are in the overlap region between secondary electron multipliers and Faraday cups. After 10^{12} Ω resistors have been introduced successfully about ten years ago, more recently 10^{13} Ω resistors have been introduced.

Upon the initiative of JRC-Geel and the nuclear safeguards community (e.g. the IAEA), a new calibration board has been introduced recently which allows the instrumentally-based inter-calibration of amplifiers with 10^{11} Ω, 10^{12} Ω and 10^{13} Ω resistors.

In this paper, first the detection system performance is described and evaluated. Secondly measurements of the gravimetrically prepared reference materials series IRMM-075 with certified $^{234}U/^{238}U$ and $^{236}U/^{238}U$ ratios at the order of 10^{-4}-10^{-6} will be presented in order to show the improved measurement performance for amplifiers with 10^{13} Ω resistors.

Furthermore a new series of reference materials certified for the uranium isotope ratios, the IRMM-2019-2029 series is introduced to the geochemistry community.