Use of 10^{12} and 10^{13} ohm resistor amplifiers for uranium isotopic measurements by TIMS and MC-ICPMS

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The determination of uranium isotope ratios is major in different fields such as geochronology, nuclear safeguards and forensics, environmental monitoring or health monitoring. Mass spectrometric techniques such as thermal ionization mass spectrometry (TIMS) or multiple collector inductively coupled plasma mass spectrometry (MC-ICPMS) are the techniques of choice for precise and accurate measurements of uranium isotope ratios. Due to the large range of uranium isotope ratio that can be encountered, particularly in the nuclear domain, different types of detection systems (Faraday cup, Daly detector, Secondary Electron multiplier..) are typically used for measurements of both major and minor isotopes. An advanced development is the fabrication of 10^{12} and more recently 10^{13} ohm resistors mounted in the feedback loop of Faraday cup amplifiers in order to improve the signal to Johnson noise ratio at low ion beam intensities.

In this work we present the results obtained with the use of Faraday cup connected to amplifiers equipped with 10^{12} and 10^{13} ohm resistors in static multicollection mode for the determination of minor isotope ratios of uranium ($^{234}U/^{238}U$ and $^{236}U/^{238}U$). Measurements are performed by TIMS and MC-ICPMS (Triton Plus and Neptune Plus, Thermo Fisher) on five IRMM standards (IRMM-183, 184, 185, 186, 187) with $^{234}U/^{238}U$ and $^{236}U/^{238}U$ ratios ranging from $4x10^{-4}$ to $1x10^{-7}$. We have compared the repeatability of isotope ratio measurements for different ion beam intensities measured with Faraday cups connected to 10^{12}, 10^{13} ohm resistors and with a Secondary Electron Multiplier. Different strategies for baseline, hydride and peak-tailing corrections have been investigated. Expanded uncertainty obtained on isotope ratio measurements was calculated in accordance with the ISO GUM and for each method the dominant uncertainty components were identified. This study demonstrate the potential of Faraday cups using new current amplifiers for precise and accurate analysis of uranium isotope ratio in nuclear or geological samples.