


実験報告書様式(一般利用課題・成果公開利用)

(※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。)

 <b>MLF Experimental Report</b>	提出日 Date of Report Jul. 26, 2011
課題番号 Project No. 2010A0051 実験課題名 Title of experiment Development of non-destructive multi-elemental analysis system by muonic X-ray 実験責任者名 Name of principal investigator Kenya Kubo 所属 Affiliation International Christian University	装置責任者 Name of responsible person Yasuhiro Miyake 装置名 Name of Instrument/(BL No.) D2 実施日 Date of Experiment Nov. 11, 2010 – Nov. 14, 2010

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。(適宜、図表添付のこと)  
 Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.
Kapton film Tempo koban (old Japanese gold coin)

2. 実験方法及び結果 (実験がうまくいかなかった場合、その理由を記述してください。) Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.
<p>In order to nondestructively measure the gold content near the surface of a Tempo koban (an old Japanese gold coin), we conducted 1) tuning the MUSE D2 line to deliver optimum number of negative muons with low momentum to stop the near surface of the Tempo koban and 2) actual measurement of the elemental composition of the koban.</p> <p>1) The MUSE facility, owing to the high momentum (3 GeV) of the primary proton beam from the Linac and RCS, was expected to provide an intense negative muon beam compared with the other muon facilities. We with the MUSE beam line construction group members checked the negative muon momentum vs. negative muon yield relationship. A Kapton film was used as the muon stopping target set in a vacuum chamber. The D2 beam line magnet settings were adjusted the muon momentum ranging from 6.4 to 10 MeV/c by scaling the setting for the surface muon beam. The result is summarized in the Figure 1 combined with the previously obtained data for higher energy muons. The muon with the momentum of as low as 6.4 MeV/c was obtained at a rate of 10 /s. This is a sufficiently high rate for elemental analysis.</p>

## 2. 実験方法及び結果(つづき) Experimental method and results (continued)

2) With the muon beam of 6.4 MeV/c and 15 MeV/c the elemental composition of the Tempo koban was measured by counting the muonic X-ray emitted from the koban with three Ge detectors. The obtained two spectra is superimposed in Figure 2 by normalized at the 30 keV Ag peak. The Au peak intensity is higher at the surface than at the deep interior. By analyzing the spectra the gold content near the surface (1.5mm depth) was estimated to be  $72 \pm 7\%$  while the deep interior  $54 \pm 4\%$ . We for the first time successfully demonstrated that the negative muon induced muon X-ray measurement could be used for elemental composition analysis of the inside of bulk materials nondestructively.

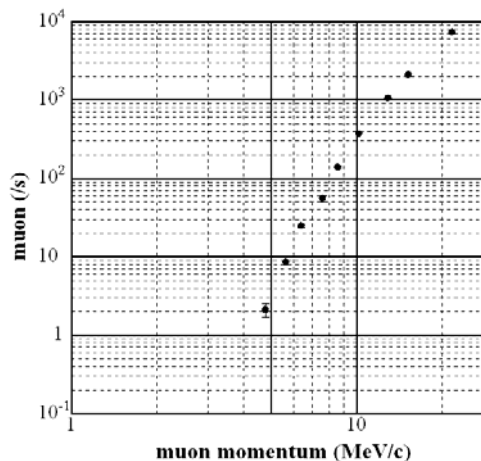


Figure 1. Yield of negative muon at D2.

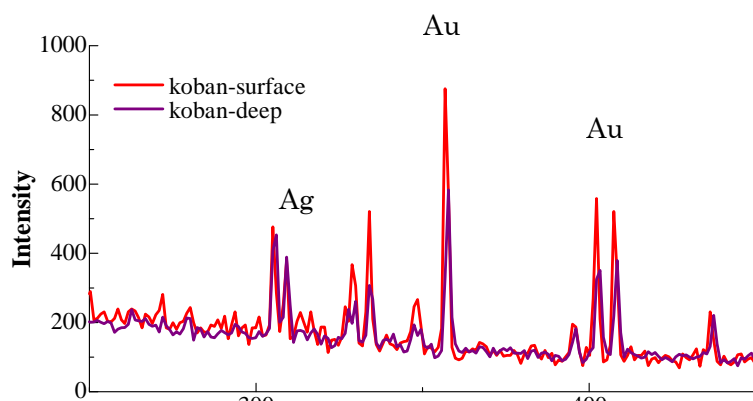


Figure 2. Muonic X-ray spectra of surface and interior of a Tempo koban.