PRELIMINARY EXPERIMENTS WITH A PYROELECTRIC X-RAY-SOURCE FOR THE DEVELOPMENT OF AXS FOR THE SCIENTIFIC PAYLOAD OF THE SELENE-2 MISSION

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Introduction: The Japanese space agency JAXA is planning and preparing their next mission to the moon, SELENE-2. It will be the first moon landing mission of Japan, involving an orbiter, a lander and a rover. The launch is scheduled for approximately 2015/2016. One of the main mission objectives is the geophysical and geochemical in-situ observation of the lunar surface and subsurface [1, 2].

One candidate for the scientific payload of the rover is an Active X-ray Spectrometer (AXS) for in-situ X-ray fluorescence measurements. The AXS will be the further development of the APXS (Alpha Particle X-Ray spectrometer), which is a significant part in the scientific payload of well-known missions like Surveyor 5-7 [3], Mars Pathfinder (MPF) [4], Mars Exploration Rover (MER) [5] and Rosetta [6].

In the new AXS the former radioactive Alpha- and X-ray-sources, containing ^{244}Cm, will be replaced by a new kind of X-ray-generators, based on the pyroelectric effect [7]. This will provide the great advantage by generating X-rays only on demand. Another improvement will be the use of a newer SD-detector with a larger surface in comparison to the detectors in former APXS versions, providing a higher count rate, and therefore higher sensitivity.

Experimental setup: To evaluate the combination of a new pyroelectric X-Ray source with a SD detector, in-situ measurements in the laboratory were performed. A Ketek AXAS-SDD with a surface of 100mm^2, 450µm thickness, Be-Fenster and Zr-collimator was used. The data acquisition was done with an Amptek Pocket MCA8000A. (Fig 1)

As X-ray generator an Amptek Cool-X was used. The contained pyroelectric crystal consists of lithiumtantalate ($LiTaO_3$), the target foil was made of Cu. Therefor mainly X-rays of specific wavelength were obtained: $Cu_{K\alpha}$ (8.05keV), $Cu_{K\beta}$ (8.90keV), $Ta_{L\alpha}$ (8.14keV), $Ta_{L\beta}$ (9.02keV), $Ta_{L\gamma}$ (10.90keV) plus a Bremsstrahlung continuum.

For the reduction of stray radiation from the generator a collimating aluminium-tube was applied. The electronic box of the detector was cooled by a recirculating cooler (Julabo FE500) to obtain an optimal energy resolution (fig.1).

Fig 1. Experimental setup; measurement of an Ortenberg basalt sample

Cool-X heating & cooling phase: When activated the X-ray generator was running cycles of heating (18sec) and cooling (86sec) phases. For both phases the radiation flux was significantly stronger during the last seconds of each phase. The duration of all measurements were chosen to be a multiple of one heating and cooling cycle time (ca. 110s).

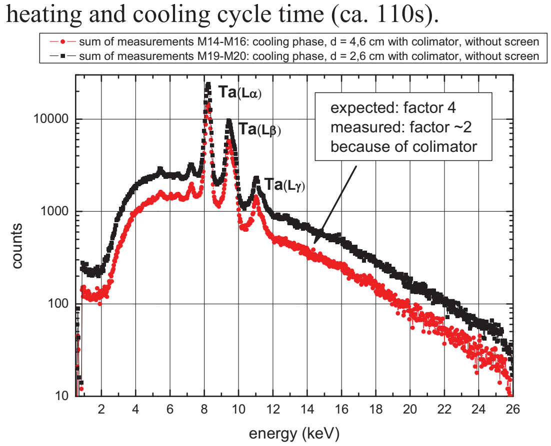

Fig 2. Emission spectrum during cooling phase

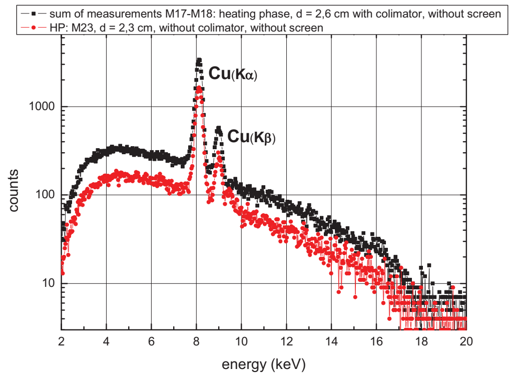

Fig 3. Emission spectrum during heating phase

To examine the temperature dependence of Cool-X, the complete X-ray generator package was tempered between 10 to 46°C. A linear increase in the over-all count rate with temperature was detectable (Fig.4).

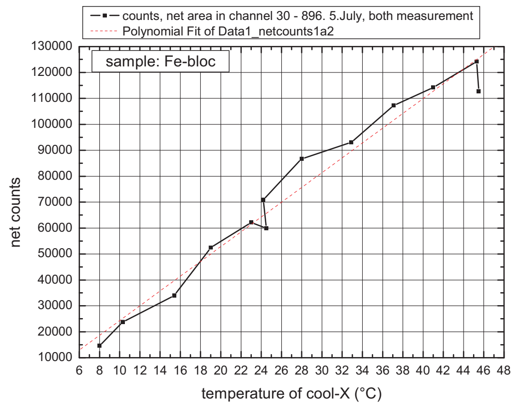

Fig.4 temperature dependence of radiation flux, sample: iron-metal.

Variations in flux in between measurements were found, when the measurement time period was chosen very short (a few cycles). The over-all count rate stabilized and got reproducible, when longer measurement times of around 20 cycles were applied. As Amptek mentions in their manual the Cool-X isn't thought for non-stop use, the lifetime of the delivered X-ray generator is limited.

Equal short measurements were repeated for 2 sequential days to examine the behavior of the Cool-X under constant usage. The comparison of the over-all count rates of the measurements showed a slow decay over the 2 days. A sort of "relaxing" of the Cool-X was observed.

Results: The new Cool-X pyroelectric X-ray generator provides an on-demand X-ray-source, small in dimensions. The combination with an actual SD-detector delivers a very capable XRF-tool with low power consumption ideal for a compact, mobile XRF-tool as needed for a space mission. For a quick qualitative elementary analysis only short measurement times are necessary. If longer measurement times are applied, or maybe more X-ray generators would be used simultaneously, reproducible results for quantitative elementary analysis are obtainable.

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