“Crono”: a reconfigurable MACRO-XRF Scanner for cultural heritage applications

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A portable and reconfigurable MACRO-XRF scanner based on the Energy Dispersive X-Ray Fluorescence technique will be presented discussing its performances. The instrument, “Crono”, has been specifically designed for in-situ, very fast and non-invasive elemental mapping of the sample. The field of application spreads over cultural heritage, industrial process, material research and elemental analysis in general.

The XRF components are fully integrated into a compact detection head (30 cm x 16 cm x 15 cm, 3 kg). The X-ray detector element is a large area Silicon Drift Detector (SDD) equipped with CMOS preamplifier (“CUBE” technology by XGLab) characterised by state-of-the-art performances. The SDD is read out by a new digital pulse processor (“Dante” DPP by XGLab) with very low noise and high count-rate performances, and real-time data transmission capability. The system is driven by an integrated controller board and an embedded PC with Ethernet or wireless connection to the external computer. The excitation source is a highly efficient and compact X-Ray generator with Rh anode. Three collimators (0.5 mm, 1 mm and 2 mm diameter) are software selectable to get different spot-sizes on the sample. A filter-set (four filters software-selectable) is also integrated in the instrument head to improve low detection limit capability in special applications. The design of the scanner allows the detection of elements ranging from Na to U with good efficiency even in region between 1 and 2keV (i.e. Na, Mg, Al, Si, P K-edge emissions) and in the region >25keV (e.g. Sn, Sb, Ba K-edge emissions). Na and Mg sensitivity can be improved using Helium flux.

The scanned area can always be monitored by the operator thanks to several control systems integrated into the compact detection head. These include two pointing lasers for alignment, a microscope camera for a detail monitor, an external camera for a larger field of view, and illumination of the point of analysis with dimming adjustment. The system works in a complete non-contact mode with an optimal focus distance of about 1cm from the sample.

The detection head is mounted on a motorized stage that allows for up to 60 cm x 45 cm area scanning (XY) and 7.5 cm focusing axis (Z). Thanks to a proper design of the mechanics, of the electronics and of the XRF components, the scanning on the sample can be performed with a speed up to 45mm/sec. This allows the scanner to perform very fast measurement. The typical measurement time ranges from few tens of minutes up to few hours depending on required spatial resolution, area size and contrast.

The system can be mounted on a trolley (see Fig.1) that allows tilting the frame between -20° and +90°, with respect to the horizontal plane. The motorized frame and the trolley can be easily dismounted for transportation. Moreover, whenever a mapping is not required, the MACRO-XRF scanner can turn into a portable spot-XRF device by detaching the measurement head from the supporting frame and using it on a light tripod. The system is completed by an advanced software interface for the complete instrument control, for the data analysis and for saving the report documentation in different format (including pdf files). As an example in Fig. 2 the XRF maps acquired from a painting scanning in 30 minutes an area of 50 cm x 40 cm with a spatial resolution of 2mm are reported.

Fig.1. The detection head and the XYZ motorized stage for automatic elemental mapping.

Fig.2. Elemental mapping on a 50cm x 40cm painting.
Line speed 20mm/s, collimator aperture 2mm, tube settings 50kVand 100uA. From the top-left, clockwise:
visible picture, Pb-Lz, Ca-Kz, Ba-Lz.