X-ray based methods and instrumentation in Materials Science

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Teaching staff

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Reception hours: upon student request

Program of the course: The course is focuses on the basic principles of X-ray fluorescence (XRF) and on development advanced XRF imaging techniques applicable to cultural heritage research, presenting figures of merit and application examples based on the use of advanced portable instruments. Related analytical methods and procedures making use of Confocal X-ray spectroscopy, Full-Field X-ray imaging, Xray Diffraction Imaging and Grazing incidence X ray spectroscopy will also be discussed.

1. Introduction - brief theoretical overview of: interaction between radiation and matter and its application in the non-destructive chemical characterization of materials: transmission, diffusion, absorption; excitation and de-excitation processes; physical principles and technology of the X-ray sources and of advanced new generation detection systems based on the use of SDD detectors, CCD cameras, HPAD detectors: their key properties and their implications in the characterization of materials. Quantitative considerations in XRF analysis.

2. X-ray fluorescence spectroscopy (XRF) and X-ray diffraction spectroscopy (XRD): basic physical principles, laboratory scale portable instrumentation, innovative experimental configurations and schemes, calibration procedures and spectra analysis, main spectroscopy software and main reference materials databases.

3. Presentation of different advanced space-resolved (2D) and depth-profiling (3D) X-ray spectroscopy techniques. Introduction to the principles of X-ray focusing by X-ray optics; principles of acquisition and data processing in real-time mode. Analytical methodologies for the Micro and Macro X-ray Imaging. Experimental development of X-ray imaging systems based on the scanning and the full-field approaches. Basic theory of the Grazing

Emission/Incidence XRF techniques and related laboratory setup.

4. Laboratory - practical demonstration on the use of advanced mobile instrumentation: scanning XRF/XRD/CXRF/GIXRF systems (technology and operational performance). Development of adequate experimental strategies for the non-destructive investigation of ancient materials: characterization of raw materials, provenance study, manufacturing techniques, conservation state, authenticity; data analysis of archeological materials and artworks of different typology and period and their interpretation.

Bibliography:

1. Romano, Francesco Paolo, Claudia Caliri, Luigi Cosentino, Santo Gammino, Lorenzo Giuntini, David Mascali, Lorenzo Neri, Lighea Pappalardo, Francesca Rizzo, and Francesco Taccetti. "Macro and micro full field X-ray fluorescence with an X-ray pinhole camera presenting high energy and high spatial resolution." Analytical chemistry 86, no. 21 (2014): 10892-10899.

2. Romano, F. P., Caliri, C., Nicotra, P., Di Martino, S., Pappalardo, L., Rizzo, F., and Santos, H. C. (2017). Real-time elemental imaging of large dimension paintings with a novel mobile macro X-ray fluorescence (MA-XRF) scanning technique. Journal of Analytical Atomic Spectrometry, 32(4), 773-781.

3. Romano, F. P., Caliri, C., Cosentino, L., Gammino, S., Mascali, D., Pappalardo, L., Rizzo, F., Scharf, O., Santos, H. C. (2016). Micro X-ray Fluorescence Imaging in a Tabletop Full Field-X-ray Fluorescence Instrument and in a Full Field-Particle Induced X-ray Emission End Station. Analytical Chemistry, 88(20), 9873-9880.