

Quantifying thin layered alloys with a reliable uncertainty budget using synchrotron radiation based experiments

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Abstract text

X-ray fluorescence analysis (XRF) is a well-established nondestructive technique to investigate a wide range of materials. While for bulk samples elemental concentrations are determined, for thin multilayer samples an additional task is to determine the individual mass deposition of each element in each layer. Quantitative results of samples are typically obtained by utilizing well-known reference samples. Thin, alloyed multilayers with layer thicknesses in the order of one micrometer were analyzed in the present work. Since for this type of material appropriate reference materials are often not available, a reference-free approach based upon SI traceability is employed by the Physikalisch-Technische Bundesanstalt (PTB), the national metrology institute of Germany. The PTB operates fully characterized X-ray beamlines at the electron storage ring BESSY II in Berlin. The radiometrically calibrated instrumentation and the reference-free fundamental parameter approach using monochromatized synchrotron radiation allow for a direct quantification of the mass deposition of individual layers in the multilayers and a reliable uncertainty budget can be calculated [1].

In multilayered samples, consisting of multiple elements, the fluorescence radiation of one element may enhance the fluorescence intensity of another. This is referred to as secondary fluorescence. The theoretical tools to calculate X-ray fluorescence intensities for quantification algorithms are well-known and can be found in the literature [2,3]. The present work aims to study the validity of these well-known higher-order algorithms by directly comparing the theoretical calculations with absolute experiments. The selected samples are thin layered and consist of multiple transition metals. For these samples the contribution of secondary excitation fluorescence can be as high as 20% or more, depending on the elemental distribution, the spatial composition and dimensions of the layered system, the excitation energy and the angle of incidence.

[1] Beckhoff, Journal of Analytical Atomic Spectrometry 23 (2008)

[2] Handbook of Practical X-Ray Fluorescence Analysis, Springer (2006).

[3] D.K.G. de Boer, X-Ray Spectrometry 19 (1990).