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Application of Quantitative and Qualitative Mapping of Materials in Forensic Practice

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Standard quantitative or qualitative mapping is widely used in forensic practice in many examinations. One of these areas is the use of the maps to identify gunshot residues and post-blast residues.[1] For example in a medialized case of an explosion, origin of thermogenetic particles in the course of explosion was proved by elemental mapping on FIB cut (SEM/FIB system). Another application of mapping is determination of superposition toner/writing paste on documents. It is used to provide the answer to whether the document was signed after the text had been printed or whether the text was post-printed onto the already printed document, etc.[2] An example from practice - there existed a suspicion that a signature of a payee on a bill of exchange was forged and the bill of exchange of CZK 30,000,000 (approx. USD 1.2 million) was asserted afterwards at a court and also that the signature of a guarantor on an exchange bill of CZK 3,252,500 (approx. USD 130,000) was forged. A handwriting expert stated that having examined strokes of the questioned signature and their immediate surroundings there were no marks of copying, pre-drawing, double strokes, erasing, indented guidelines or another kind of technical forgery and it is most probably an authentic signature. It was necessary to prove whether first there was the signature or the print. Once again, the SEM/FIB system was applied. In the area of the stroke of the acceptant the toner particles were melted onto the blue writing paste with distinct layers in superposition: toner particles – writing paste – paper fibres. It was possible to make an unambiguous conclusion that the signature of the payee was added to the bill of exchange before the electrographic print was made.

Further, mapping can be used for a detailed study of paint layers on paintings to determine authenticity of works of art. Current markets, especially the one with modern art, are flooded with counterfeits identification of which is rather difficult and requires initial non-destructive techniques – photography and video analysis, multispectral imaging (from the UV spectrum up to the infrared), X-ray imaging and, further, mobile analytical techniques – point analysis and mapping using XRF and Raman spectroscopy. Using this information, sampling locations for micro samples are determined, where the mapping techniques are further applied from the SEM/EDS/WDS, micro XRF to mapping in the Raman spectrum.

A prototype device for robotic analysis, imaging and mapping of 3D objects in forensic area is being tested to be used in the aforementioned areas. The system´s principle is integration of imaging and analytical technologies onto six-axis robotic arms which allow wide flexibility range concerning the sample size or shape. The system allows non-destructive examination of wide spectrum of samples with complicated curvatures. The new generation of X-ray imaging detectors provides a high picture quality with a spatial resolution level in the micrometer range in 2D or 3D imaging. The basic version of the robotic scanner allows transmission X-ray imaging and mapping of the individual photons with high sensitivity and resolution detectors. These detectors are the result of an intensive international cooperation led by the CERN laboratory in Geneva. [3] The particular used type of imaging detectors allows to measure X-ray wave lengths. From the changes in the X-rays spectrum after it has gone through the sample, it is possible to presume the elemental composition of the examined object. Differences in spectrum changes then reflect in the resultant image in the form of false colours. Another extension modality is XRD phase mapping which exploits properties the Timepix3 spectral imaging detector which records the position and energy of every detected photon as well as the time of detection. Regarding these properties, a monochromator can be left out from the XRD device. The construction fundamentally simplifies the XRD device and allows integration with robots. The robotic scanner further allows scanning and mapping of crystallic properties of the whole examined object on surface. This information is further combined with the XRF elemental mapping of the whole object. There exist many possibilities how to combine the XRF data with transmission maps and X-ray imaging data – a robotic scanner measures all analytical modalities in a common reference system. The system is supplemented with other modalities which allow to obtain more analytical data – VNIR, SWIR and the UV modules. The use of this information is very wide. The individual image layers can be switched on and arbitrarily combined with the obtained maps. In the forensic field, the use is rather extensive – not only for works-of-art analysis but also in tools and marks examination, forensic defectoscopy and metallography and other areas [5].

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