18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 398–399
Paper #310

ENERGY SENSITIVE X–RAY IMAGING WITH PIXEL STACK DETECTOR

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Abstract: *Material decomposition based on dual energy X–ray radiography which was primarily developed for tissue differentiation in medical imaging can be favorably used for composite material examination. The principle of this method is obtaining several absorption images of the sample with different energy spectra which allows for the identification of main material components. The need of measurement at several X–ray spectra can be achieved either by alternation of the tube voltage and/or by the use of additional filters. The single photon counting pixel detector Medipix allows direct energy discrimination of registered radiation enabling spectrum selection at the detector side without the need to first modify the X–ray source spectrum. Our approach provides moreover low noise images with broad dynamic range and thus high sensitivity and enhanced contrast. Utilization of a 3D voxel detector with two or more sensor layers allows obtaining all required images simultaneously in a single exposure. The results of the material decomposition obtained with the Medipix detector are presented and discussed in this contribution.*

Keywords: ***energy sensitive X–ray radiography, Medipix, signal to thickness calibration, material decomposition***

1. Introduction

To evaluate material differences it is necessary to measure the same sample in several energy ranges (the differences in material attenuations are then pronounced). One of the ways how to achieve this is to use the 3D voxel detector structure. Individual detector layers then work as spectrum filters – only the first layer is illuminated by the original spectrum while the others are illuminated by the spectra filtered by previous layers. This filtering effect can be further enhanced by the change of the individual sensitivity of the detector layers (by threshold shifting). Intensity data measured with the 3D voxel detector are measured on all layers at the same time. Then it is necessary to convert them to the equivalent thicknesses of the reference material. The material separation is done by the decomposition of the measured material vector to the chosen (base) material vectors

2. 3D Voxel Detector Based on Medipix Chip

The 3D Voxel detector is a modular device consisting of several layers of Medipix chips (each layer can be considered as a 2D detector), interconnected in a daisy-chain structure.The readout chips used for this device were thinned to 120 μm (from their manufactured standard thickness of 740 μm) to decrease the thickness of the insensitive material between the individual detector layers.

3. Decomposition into Two Base Materials

The basic test for the estimation of reliability of this method can be measured on an overlaying segmented phantom. The chosen phantom was composed of perpendicular aluminium and paraffin segments. Each combination of thicknesses can be used as one validation point (the mean values from each thickness combination were taken).

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The result of equivalent thickness decomposition to two base vectors (aluminium and paraffin) is shown in figure 1 below together with the decomposed aluminium thickness in the phantom.

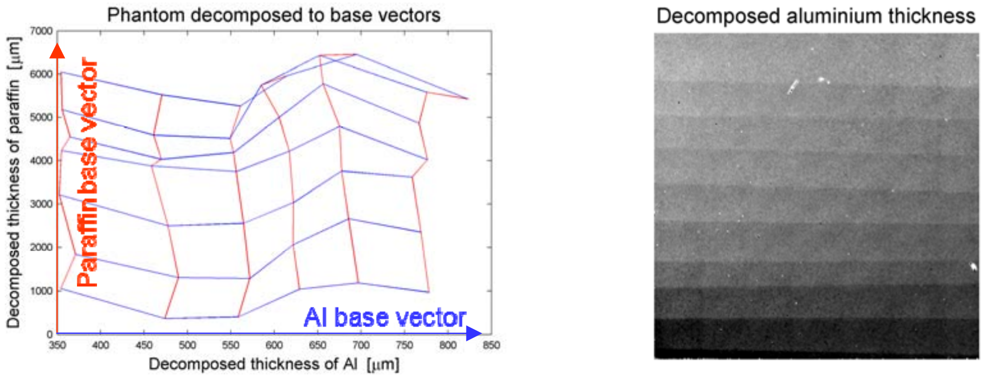

Fig. 1: Decomposed thicknesses for overlaying segmented phantom (left). Red lines represent paraffin steps (constant aluminium thickness) and blue lines represent aluminium steps (constant paraffin thickness) (left). Area distribution of aluminium in the sample (right).

4. Practical application of the method – composite sample

This method can be used for composite samples where the exact composition is not known or when it would be very hard to create reference samples of pure materials contained in the inspected object. The idea then is to do the decomposition to pseudo-materials (simply soft and hard components in this article but it can be as well a characteristic mixture of materials (colour pigment etc.)) As a testing object for the pseudo-material decomposition, the replica of a painting was used (painted with metallic pigments).

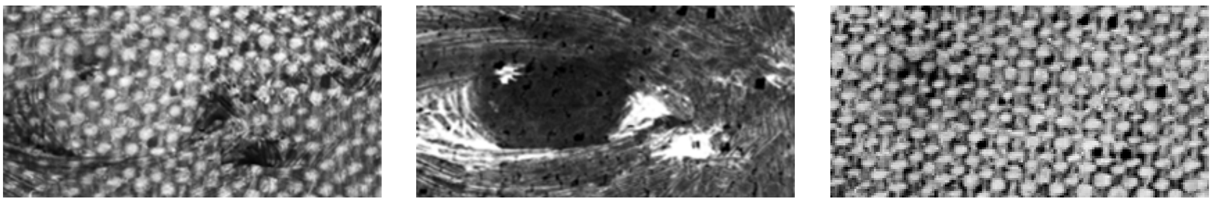

Fig. 2: Radiography of the eye area in the painting (left) and the result of the material decomposition into two components. The hard component group (middle) and soft component group (right) were separated. Two acquisitions were needed for this decomposition – the sample was shifted after the first acquisition to double the inspected area.

5. Summary

It has been demonstrated that material decomposition method can evaluate the radiographic data obtained with the 3D voxel detector assembled from Medipix family detectors. The advantage of this device lies in the possibility to take pictures in all subsequent detector layers at once. Moreover the front layers themself work as an energy filter for the layers behind. When the material composition of the sample is known it is possible to directly calibrate the method and to carry out the material decomposition into the chosen components. In other cases when the sample composition is too complex it is still possible to group all materials with similar properties into pseudo-materials and use them for the decomposition.

Acknowledgement

This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic under Research Center No. LC06041 and by Grant No. P105/11/1551 of the Grant Agency of the Czech Republic. Research carried out in frame of the Medipix Collaboration.