Diamond Light Source Experimental Report

MT16144: Phase-contrast nanotomography of asbestos bodies in human lung tissue

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1. Abstract

The aim of this experiment was to reveal the distribution of asbestos bodies (i.e. the ensemble of asbestos fibre and its ferruginous coating) in fragments of human lung tissue from workers who have been exposed to asbestos for years, and their possible preferential association with pulmonary structures (alveoli, bronchioli…). This aim has been successfully achieved by exploiting cutting-edge x-ray phase-contrast nanotomography at the I13-2 beamline

successful experiment obtained at I13 at average resolution (0.33 and 0.67 μm), which allowed to determine the spatial density of the asbestos fibres and possible accumulation points in the biological tissue.

2. Experiment details

Working energy (monochromatic beam): 14.7keV
Detector: PCOedge5.5 2560 x 2160 pixel; pixel size 6.5 um
Two experimental setups where used:

Magnification: 8x
FOV: 2.1 x 1.8 mm^2
Resolution: 0.8μm
Sample to detector distance: 15cm (optimized to allow for phase-contrast regime)

Magnification: 20x
FOV: 0.83 x 0.7 mm^2
Resolution: 0.33μm
Sample to detector distance: 5cm (optimized to allow for phase-contrast regime)

3. Results

Tomography data acquired were at I13-2. 2400 projections were acquired rotating the sample between 0 and 180° and exposing for 0.6s. Figure 1a shows tomographic data acquired at a resolution of 0.8μm on a fragment of lung tissue embedded in paraffin after having being fixed in formalin. Asbestos bodies are clearly recognizable as the white elongated objects having, sometimes, typical segmented structures along the longitudinal axis. To show a higher number of asbestos bodies, the figure is the result of the projections of 100 slices on the Z-axis. Pulmonary structures are clearly visible in the background, confirming the advantage of phase contrast in revealing both highly low absorbing matter (as are respectively asbestos bodies and lung tissue). Data where acquired on biological samples contaminated with asbestos from 4 subjects. Three volumes were acquired for each subject to image an entire sample, which was cut from a paraffin block in dimensions suitable for full field tomography (cores of about 1-2 mm in diameter). For the higher resolution setup, half acquisitions (0-360°) where performed.

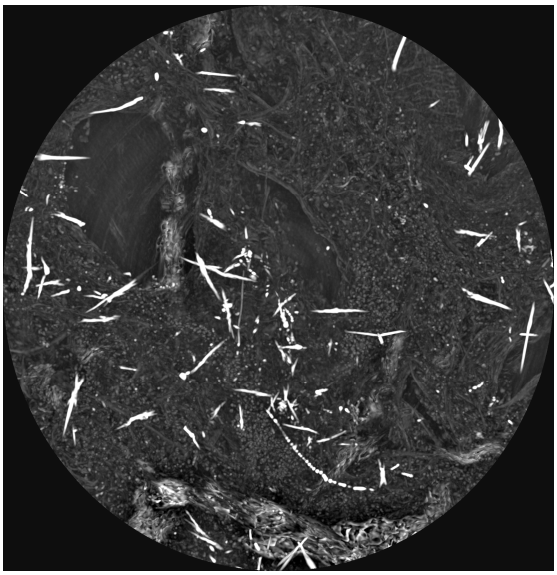

Figure 1a. Tomographic resconstruction of a lung tissue sample with asbestos bodies (100 slices projected on the z-axis, pixel size 0.8μm).

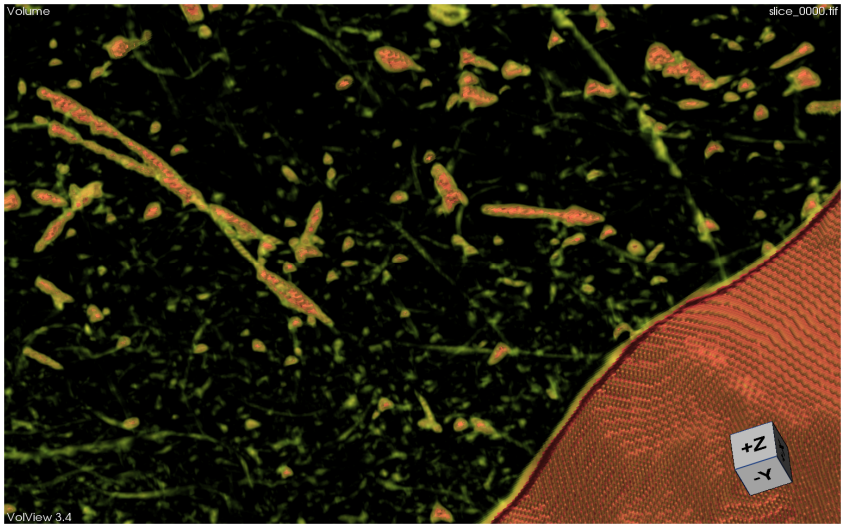

Figure 1b. Volume rendering of a lung tissue sample with asbestos bodies (pixel size 0.33 μm).

4. Conclusions and future work

The acquired data will allow revealing possible preferential association of the asbestos bodies with the pulmonary structure. The data will also allow to correlate the asbestos bodies count (number of asbestos bodies per gram of dry tissue), which was performed by digesting the tissue and counting the bodies with a SEM, with their spatial density revealed by tomographies.

5. References

Bardelli, F. et al. New insights on the biomineralisation process developing in human lungs around inhaled asbestos fibres. Sci. Rep. 7, 44862; doi: 10.1038/srep44862 (2017).

6. Publications resulting from this work

An article with complementary TEM measurement is foreseen to be published within 2018.

Note:

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