

# Characterization of wood microstructure by synchrotron radiation-based x-ray microtomography (SR $\mu$ CT)

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Wood is a versatile tissue complex composed of different cell types such as tracheids, fibres, vessels and parenchyma cells, that each fulfils specific tasks within the woody body of a tree. However, even within a tree genus wood structure can differ significantly due to either biotic or abiotic stress factors occurring during the growth season, or due to cultivar specific growth characteristics. Typical tools for structural analysis of wood are scanning electron microscopy (SEM) and light microscopy, allowing measurements of sectional planes. SEM imaging reveals a distinct 3D view and can be applied with a very high resolution of the sample, but is limited in volumetric analysis. An example of poplar wood presenting the cross- and radial sections is given in Figure 1A. Here, different cell types of poplar wood are clearly visible and scheme of structural order is also clearly apparent. However, the detection of boundary surfaces between neighbouring cells and interconnectivity can only be observed in a restricted dimension (Fig. 1A). Light microscopical analysis allows an exact measurement of wood cells in a two-dimensional plane and additionally reveals insights in cell properties through respective staining techniques (Fig. 1B) [1].

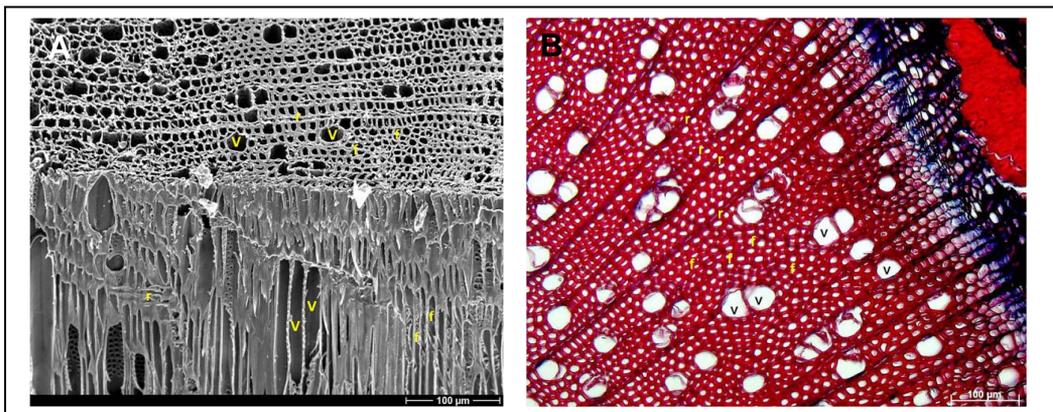


Figure 1: A - SEM image of poplar wood sample. Cell types are clearly detectable, interconnectivity and expansions are only measurable in a limited way. B - Light microscopic image of a 16  $\mu$ m thin poplar wood cross section stained with safranin and astra blue. Cell types are clearly detectable and can be measured in a 2D manner. v-vessels; r-ray parenchyma; f-fibre.

In our investigations at DESY, we applied SR $\mu$ CT operated by HZG at the BW2 Beamline of the HASYLAB for characterization of small wood samples (*Populus trichocarpa*) to get a three-dimensional image of a small-scale sample, thus allowing in a non-destructive way to visualize size, volume, form and interconnectivity of the cells on a microstructural level. The sample was analyzed using the photon energy of 9 keV. The effective pixel size in the data set is 3.26  $\mu$ m. The total scan volume consists of 1536\*1536\*1023 voxel representing a volume of 5.0\*5.0\*3.3 mm<sup>3</sup>.

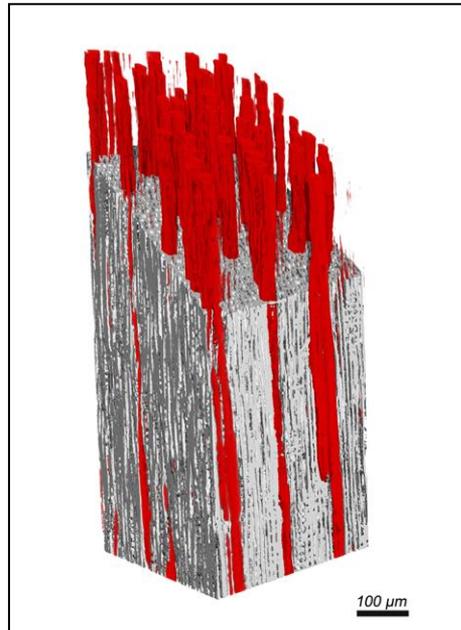


Figure 2: SR $\mu$ CT allows 3D analysis of a poplar wood sample. Water transporting vessels are presented in red. Only a small section of the total sample volume is visualized.

Using VGL StudioMAX as imaging software (Volume Graphics GmbH, Heidelberg, Germany), different cell types of the polar wood sample could be visualized and emphasized, such as the water transporting vessels (Fig. 2). The hollow space of the vessels has been coloured and the surrounding woody tissue extracted, thus presenting the interconnectivity of water transporting vessel network in a 3D manner.

In conclusion, SR $\mu$ CT is a great tool for visualization of connectivity and form of different cell types within a wood sample. Dependent on initial sample size, high resolution of microstructure can be gained. The technique is promising to calculate volumes, e.g. of water transported in vessels. Since it is possible to reconstruct the vessel network of a stem section, effects of wounding or other environmental stresses on the xylem structure in general, and particularly on the water transport system, can be detected and visualized in 3D by synchrotron radiation – based x-ray microtomography.

## References

- [1] D. Janz, S. Lautner, H. Wildhagen, K. Behnke, J-P. Schnitzler, H. Rennenberg, J. Fromm, A. Polle, *New Phytol.* DOI: [10.1111/j.1469-8137.2011.03975.x](https://doi.org/10.1111/j.1469-8137.2011.03975.x), Article first published online: 29 NOV 2011.