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High-dose effects in high-resolution X-ray microscopy of soft materials

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High-resolution X-ray microscopy is used as a complementary approach to electron microscopy for non-destructive imaging of soft materials, including biological tissues, e.g. frozen hydrated [1] or heavy metal stained resin-embedded [2] brain tissues. For this purpose, photon energies above about 2 keV are used to penetrate tissues of about 100 micron thickness or more, for which samples exhibit a very low contrast. To overcome this challenge, phase-contrast hard X-ray microscopy methods are typically used in synchrotron beamlines, reaching a resolution of about 100 nm. The available coherent flux and the changes in the sample structure due radiation are among the main challenges to improve spatial resolution in hard X-ray microscopy of soft materials. Next generation synchrotron sources provide high brilliance, which offers a great opportunity to improve resolution. However, this will require the development of new approaches to mitigate the effects of radiation in soft materials.

Here, we present our experience when applying ptychographic X-ray computed tomography (PXCT) [3] to soft materials. In polymer samples or resin-embedded biological tissues, we observe deformations, such as expansion or contraction of the sample, and mass loss above a certain X-ray dose exposure [4]. For samples that deform during acquisition, we apply a non-rigid tomographic reconstruction to recover the original 3D structure of the specimen [5]. For resin-embedded biological tissues, we have identified a resin which is more resistant to hard X-ray radiation compared to standard epoxy resins used for EM [4]. Finally, we explore acquisition strategies and sample preparation protocols that minimize the effect of radiation.

References

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