X-ray ptychographic tomography: high-resolution 3D imaging with quantitative contrast

Ana Diaz

Paul Scherrer Institut, Switzerland

ana.diaz@psi.ch

Ptychographic X-ray computed tomography (PXCT) is a coherent diffraction imaging technique that provides the three-dimensional (3D) electron density distribution of specimens with high spatial resolution and quantitative density contrast [1]. Despite stringent requirements such as coherent illumination and nanometer scanning position accuracy, it has been shown that the resolution in PXCT can be pushed below 20 nm in 3D [2] with acquisition rates reaching 5600 resolution elements/s [3] on specimens with small features exhibiting high density contrast. Moreover, measurements are also possible under cryogenic conditions, which enable imaging cryogenically preserved biological tissue [4] and can also mitigate structural changes due to radiation damage in other sensitive specimens. Therefore, PXCT offers today a unique non-destructive characterization tool with a resolution approaching that offered by electron microscopy techniques.

Up to date all reported PXCT measurements have been performed at 3^{rd} generation synchrotron sources. In comparison, diffraction-limited storage rings provide an increase of the coherent fraction of the beam by a factor of about 40. Furthermore, other technical upgrades could increment the flux in PXCT measurements by another factor of 50 compared to current experiments. The correspondingly large improvement expected in the performance of the technique makes us dream of scientific applications that are not possible to accomplish today. In this presentation I will introduce the technique of PXCT and its implementation at the Swiss Light Source with a few examples of current applications. Finally, I will give an outlook of the exciting opportunities that 4^{th} generation synchrotron sources offer, without forgetting about the challenges that we will have to overcome.

References

[1] M. Dierolf *et al.*, Nature **467**, 436-439 (2010)

[2] M. Holler *et al.*, Sci. Rep. **4**, 3857 (2014)

[3] M.Holler *et al.*, Nature **543**, 402-406 (2017)

[4] S. Shahmoradian *et al.*, Sci. Rep. **7**, 6291 (2017)