Artifact-free XUV Coherence Tomography with quantitative material sensitivity

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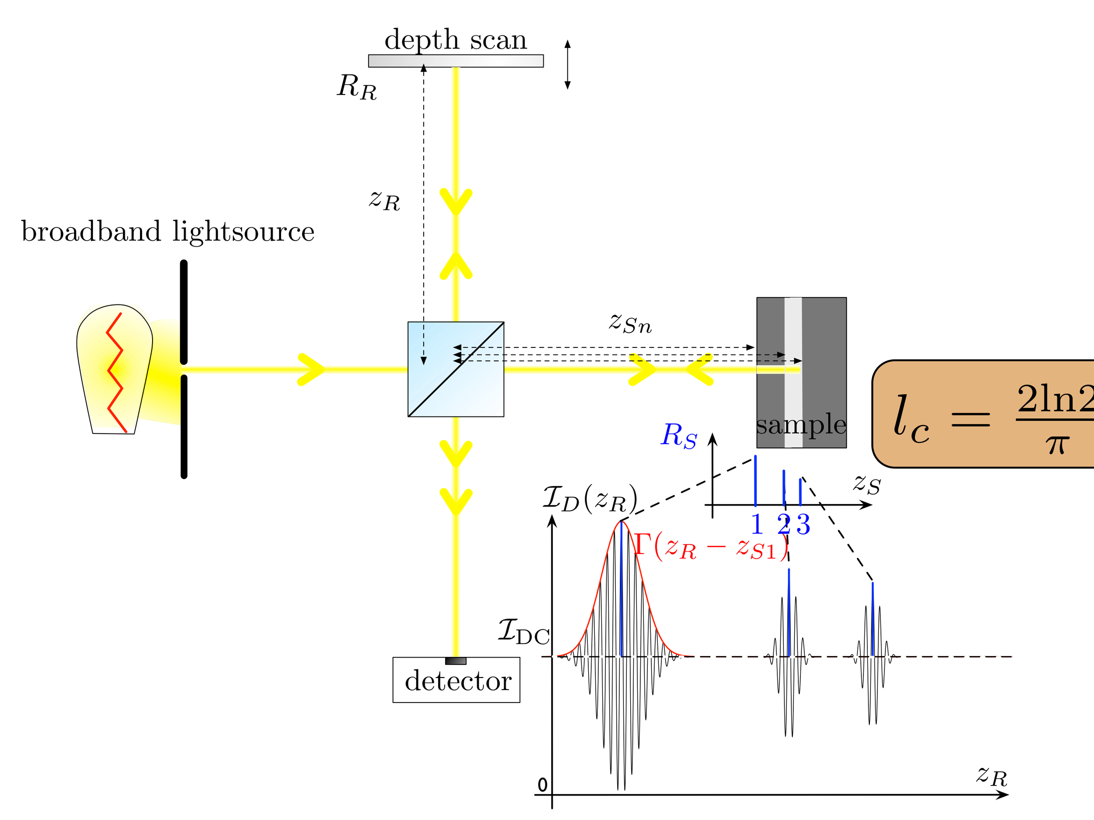
MOTIVATION

- **XUV wavelengths enable nanoscale resolution**
- **High Harmonic Generation provides broad bandwidth XUV radiation on a lab-scale**
- **XUV Coherence Tomograohy (XCT), which is an extension on Optical Coherence Tomography (OCT) [1] into the XUV uses full photon flux to achieve nanometer depth resolution**
- **A HHG source based on an OPA has been developed for XCT [2]**
- **XCT enables nondestructive cross-sectional imaging**
- **Broadband spectral information yields material sensitive contrast**

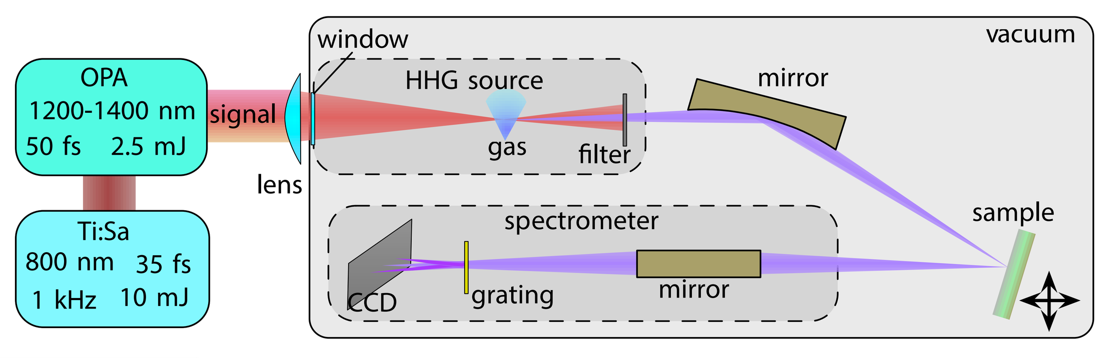
XUV COHERENCE TOMOGRAPHY

OCT-Setup

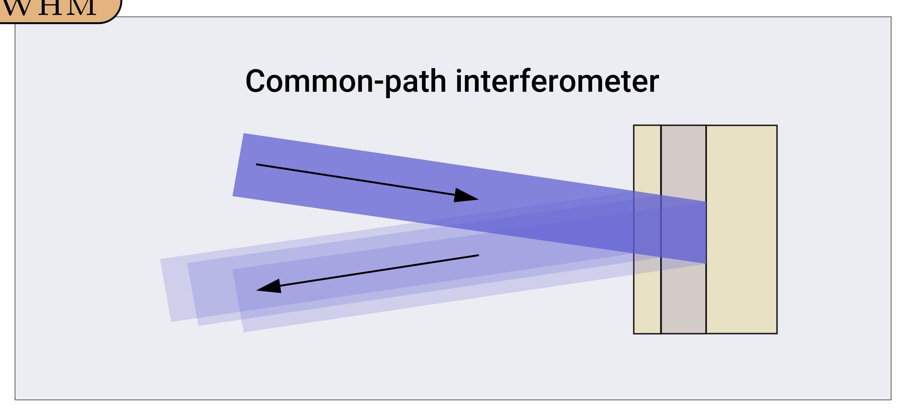


$$l_c = \frac{2\ln 2}{\pi}\frac{\lambda_0^2}{\Delta\lambda_{\mathrm{FWHM}}}$$

XCT-Setup



XUV Spectrometer
T-REXS [3]



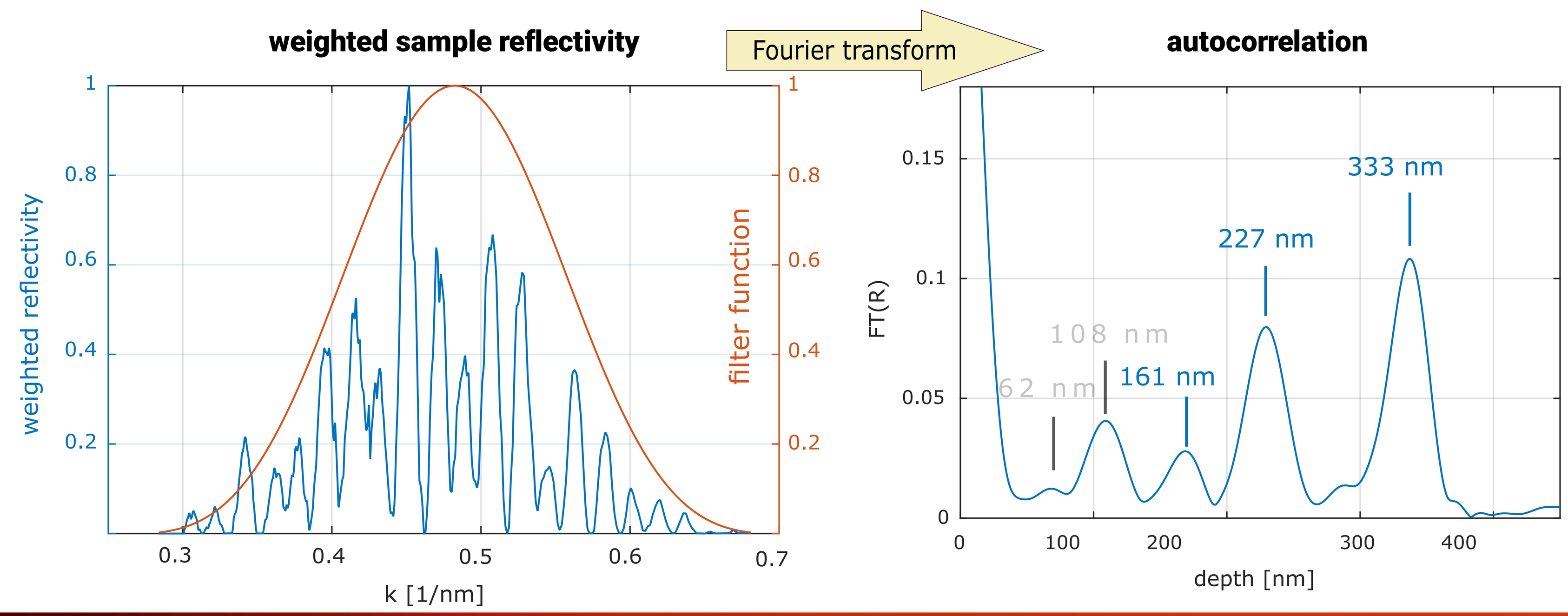
- **Broadband radiation in the XUV enables nanoscale axial resoltion (11nm within 12-42nm bandwidth)**
- **Depth structure is encoded in modulations of the reflected spectrum (Fourier-Domain XCT)**

DEPTH RECONSTRUCTION

- **Measurement of the sample's reflectivity R(ω)**
- **Transform measured signal into k-space to include dispersion and geometry of the setup**

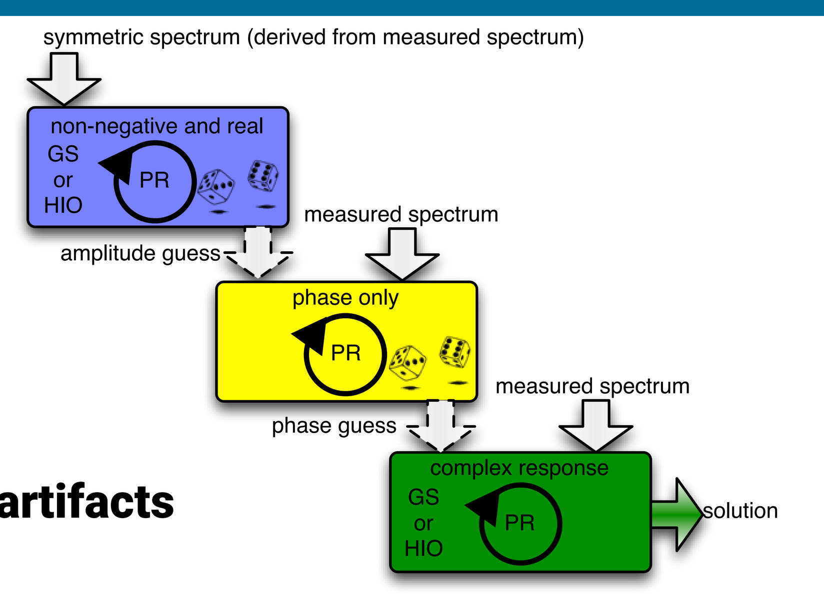
$$k = \frac{2\omega}{c}\sqrt{n_{\mathrm{Si}}^2(\omega) - \cos^2\alpha}$$

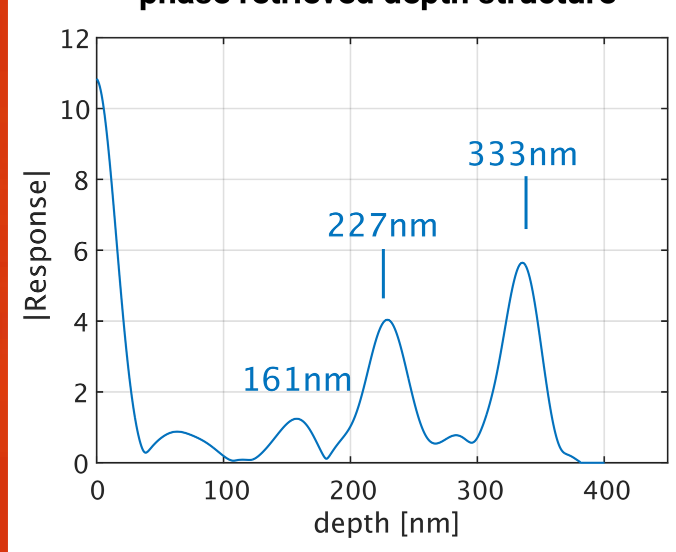
- **Fourier transform leads to autocorrelation of the axial structure (includes autocorrelation artifacts) [4]**

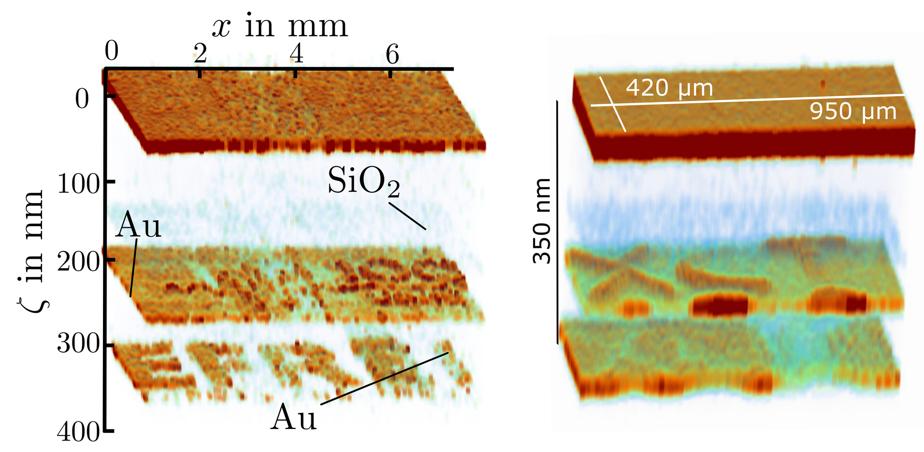


ARTIFACT MITIGATION

- **Real structure information is encoded in unknown spectral phase**
- **1D phase retrieval usually is highly unstable**
- **Novel phase retrieval algorithm [5] converges stepwise eliminating the artifacts**

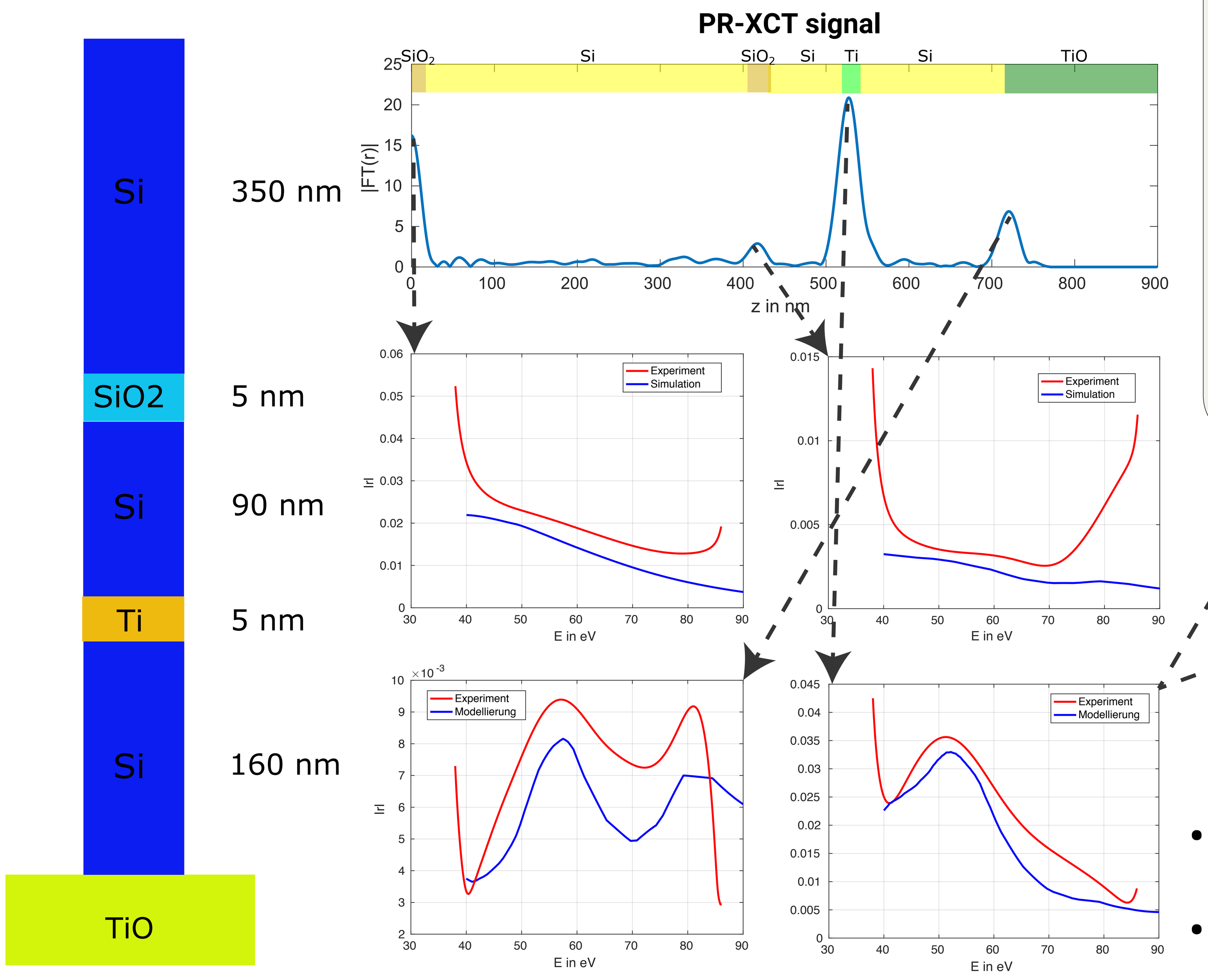


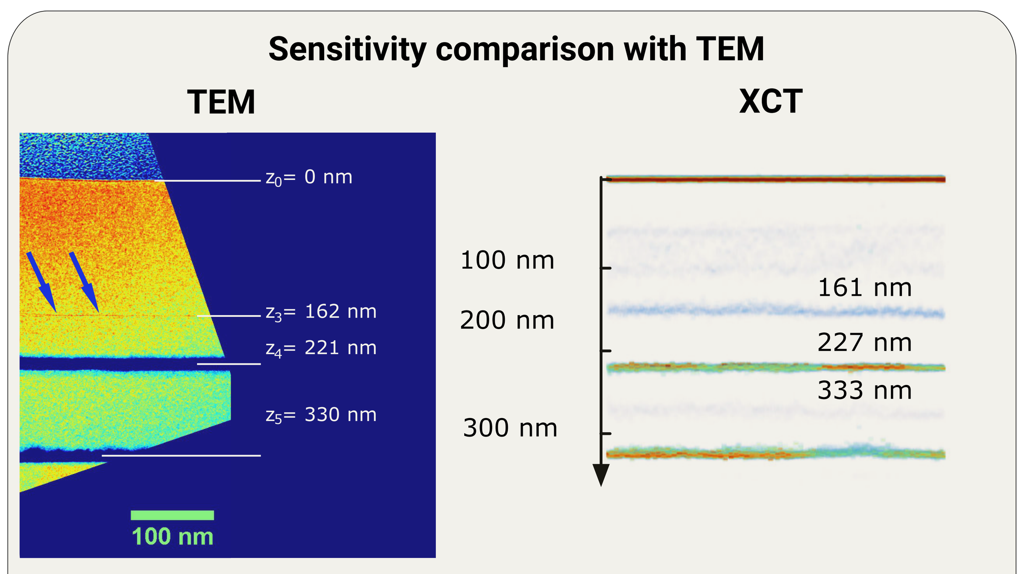




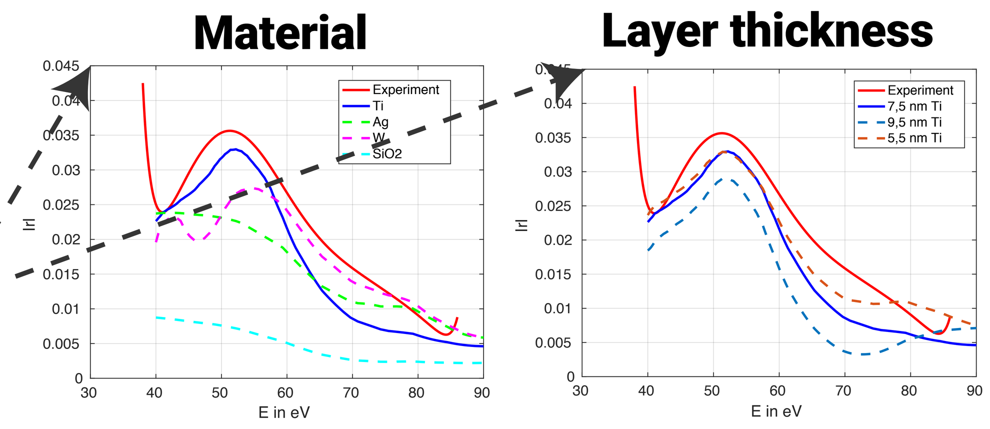
MATERIAL SENSITIVITY

Additional reconstruction of spectral layer reflectivity





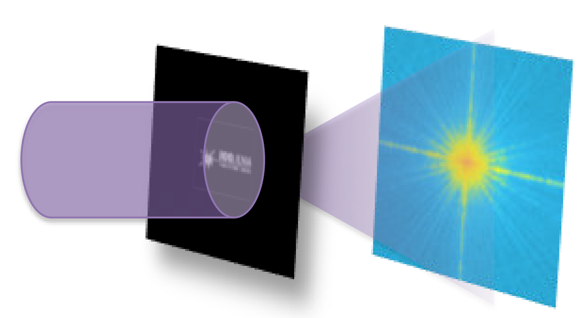
sensitivity to SiO_2 better than TEM



- **Layer thickness fits to XRR measurements**
- **Thickness measurement below axial resolution**

OUTLOOK

- **Improve the lateral resolution by using high-NA optics**
- **Combine XCT with lensless imaging techniques like CDI**
- **Add ultrafast time resolution in a pump-probe scheme**
- **Transfer laser-based XCT into the water window to increase axial resolution even further and enable better material contrast**



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