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Perspectives of Laboratory X-ray Computed Tomography for High Resolution 3D Microstructure Analysis of Materials

Ehrenfried Zschech[1], Kristina Kutukova[1], Jendrik Silomon[1], Juergen Gluch[1], Emre Topal[2], Peter Krueger[1], Markus Loeffler[2]

1 Fraunhofer Institute for Ceramic Technologies and Systems, D-01109 Dresden, Germany
2 Dresden Center for Nanoanalysis, Center for Advancing Electronics Dresden, Technische Universität Dresden, D-01187 Dresden, Germany

High-tech products or their internal components often have geometrical dimensions or microstructure features in the micro- and nanometer range. High-resolution 3D characterization of these materials and structures is needed for materials development, process control and quality assurance. Currently, two types of laboratory-based XCT setups, micro XCT in projection geometry with a resolution of about 1 µm and nano XCT with focusing X-ray lenses with a resolution down to about 100 nm, are available commercially for nondestructive two- or three-dimensional inspection of medium and small sized objects, as well as object interiors and materials' microstructure components. Because of their ability to reveal structural characteristics, materials' microstructure and flaws, such as cracks and pores, or local composition and density differences, they are potential techniques for imaging of micro- und nano-structured objects [1]. Examples for high-resolution X-ray imaging will be shown: Metallic parts and printed functional stuctures fabricated using additive manufacturing, crack propagation in composites and failure localization in metal interconnects for 3D-stacked microchips, advanced multi-component materials (e.g. composites and porous or skeleton materials) as well as biological objects (e.g. pollens and diatoms).

In this talk, perspectives of micro XCT and nano XCT for nondestructive 3D imaging of materials and biological objects will be provided, including discussion of challenges of sample preparation for X-ray microscopy and nano XCT. It will be shown that laboratory-based X-ray imaging techniques with several resolution ranges have a huge perspective for materials science and engineering. Potential and limits of these XCT techniques for nondestructive evaluation of geometrical features, materials' microstructure and flaws will be discussed. Perspectives to overcome two major limitations of state-of-the-art nano XCT tools, i.e. the necessity of sample preparation (typically less than 50 □m thickness, depending on the material composition, if 8 keV photons are used) and low imaging throughput, will be given. A novel tool concept for X-ray microscopy at high photon energies, using advanced X-ray sources with high flux and the option of multi-energy photons, and of advanced X-ray optics with high efficiency at photon energies > 10 keV, will be presented.

[1] E. Zschech et al., „Laboratory Computed X-ray Tomography – A Nondestructive Technique for 3D Microstructure Analysis of Materials“, Pract. Metallogr. 55, 539–555 (2018)

Presenting author: Ehrenfried Zschech
Fraunhofer IKTS Dresden
Maria-Reiche-Strasse 2
01109 Dresden
Germany
Email: ehrenfried.zschech@ikts.fraunhofer.de