Synchrotron radiation based imaging methods for industrial applications at the German synchrotron ANKA

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ANKA is a synchrotron facility at the Forschungszentrum Karlsruhe (Karlsruhe Research Center), operated by the Institute for Synchrotron Radiation (ISS) with user operation since 2003. As large scale facility of the Helmholtz Association of National Research Centers, ANKA is part of the national and European infrastructure offered to scientific and commercial users for performing excellent science and technological development.
Commercial users have full access to professional services of the ANKA facility and the FZK infrastructure on a contractual basis via ANKA's commercial services (ANKA COS).
In 2005 an imaging group has been established within the ISS for the development of instrumentation and methods and their application in scientific users' and commercial customers' projects. Currently a bending magnet beamline called TopoTomo is available for imaging, a dedicated insertion device beamline is under construction and via external cooperations (University of Karlsruhe, European Synchrotron Radiation Facility) further experimental stations are accessible. The imaging group also has a leading role in a European research project for the development of novel X-ray detectors based on thin scintillating crystals ($SCIN^{TAX}$). These detectors will be characterized and used at TopoTomo for topography and microtomography.
White beam synchrotron topography as performed at TopoTomo is based on recording a Laue pattern of reflections where each reflection contains a topograph from the same investigated crystal position. The patterns are collected on normal or high resolution X-ray films or via digital X-ray cameras. The method is of high interest for the semiconductor industry as topographs deliver, in a non-destructive manner, information about crystal defects, e.g. dislocations and dopant inhomogeneities within a single crystal. For example, white-light topography of a selected area of a 300-mm Si wafer using a digital image detector allows to efficiently detect and visualize local defects anywhere in the wafer. These defects can lead to failures and losses in the production of semiconductor devices. Furthermore, ISS is active in extending X-ray topography to more general diffraction imaging schemes (e.g., rocking-curve imaging) that can be used to investigate such phenomena as stress and strain in crystalline materials.
High-resolution and phase-contrast radiography are used to investigate micro-structured, multi-component material systems, e.g. to detect delaminations between substrates and glob tops encapsulating wire-bonded devices. Radiographs taken from different projection angles for computed micro-tomography allow to image objects in three dimensions with a spatial resolution down to the sub-micrometer range, e.g. bio-ceramics in regenerating bone tissue. The application of 3D image analysis methods derived from stochastic geometry can be used for the determination of size distributions, orientations or spatial correlations within the tomographic, multi-constituent volume images.
Recently, synchrotron-radiation computed laminography has been implemented at the ESRF beamline ID19 by members of the ISS Imaging group in order to image flat and laterally extended objects with high spatial resolution in three dimensions. Flip-chip bonded and wire-bonded devices are examples which show the potential of this method for typical industrial microsystem application like the detection of mm-sized voids within flip-chip solder bumps.