The Liquid-Metal-Jet X-ray Source: A New Type of Brilliant X-ray Source for X-ray Analytics in Science and Industry

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High-end X-ray diffraction and scattering experiments, such as protein crystallography, high-resolution X-ray diffraction and small angle scattering on biological samples, as well as X-ray imaging techniques strongly rely on the brightness of the X-ray source in order to obtain maximum resolution in a reasonably short period of time. The brightness of an X-ray source is usually defined as the number of photons emitted per second per unit solid angle and unit area. Modern microfocus X-ray sources define the state-of-the-art for most demanding X-ray analytical applications. These sources are usually combined with multilayer X-ray mirrors as monochromators and beam shaping devices to match the beam properties, such as beam cross-section and divergence, to the requirements of the experiment. By this, most of the source brightness is conserved ensuring maximum resolution and signal-to-noise ratio for the experiment.

The brightness of traditional X-ray sources using solid metal targets is in general limited by the power loading capability of the anode which is determined by the thermal properties of the anode material and by the heat dissipation mechanism. In conventional solid-anode technology, the power loading is typically far below 50 W/mm² and is limited by the need to maintain the surface temperature of the target well below its melting point in order to avoid damaging the target. The recently introduced liquid-metal-jet technology has overcome this limitation by using an anode that is already in the molten state. Just like conventional rotating anode generators and microfocus sources, the liquid-metal-jet X-ray source uses the impact of electrons onto a metal target to generate X-rays. However, the solid anode of conventional generators is replaced by a high-speed jet of liquid metal that can accept power loads that exceed 100 W/mm² significantly. The molten anode is regenerative by nature, with the metal jet supplying fresh target material in a close cycle at a speed exceeding 50 m/s. This technology has over the last years been developed into a stable and reliable source for home-lab systems. In combination with dedicated high quality multilayer mirrors, the result is an X-ray beam that is much brighter than what is currently achievable with a solid-anode home source.

This presentation will review the current status of the technology and demonstrate the impact of the liquid-metal-jet X-ray source on the data quality for several applications, such as protein crystallography, small angle scattering and phase-contrast imaging.