# Novel imaging modalities enabled by multilayer Laue lenses

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Multilayer Laue lenses (MLLs) are the latest addition to the family of high-resolution X-ray optics. A MLL focuses X-rays only in one direction (just like a cylindrical lens or one-dimensional zone plate), so two MLLs with slightly different focal lengths are needed to produce a focused spot. Focusing to nanometer size beams is achievable but it requires structures fabricated to nanometer precision. Thestructures prepared in our lab using magnetron sputtering are typically 100 µm tall (aperture size) with focal lengths of about 1 to 15 mm, fabricated from many thousands of layers, each several nanometers thick [1]. These layers vary in spacing so as to diffract collimated light to a common focus according to the construction of Fresnel zone plates.For high efficiency, the thickness of these lenses must be several microns or even several tens of microns, depending on the multilayer materials and photon energy.The diffraction of such thick structures is governed by Bragg's law,implying that the layers must be tilted so as to reflect rays towards the focus. To obtain a high numerical aperture (NA) lens the layers have to be "wedged", meaning their interfaces must lie normal to a cylinder of radius equal to twice the focal length.

The development of our MLLs is guided by a wavefront characterization method based on a combination of interferometry and ptychography [2-3]. This enabled us to achieve a record focusing to sub-3 nm [4] and 3D imaging with sub-10 nm resolution of complex structures [5]. In this talk, novel imaging modalities enabled by high NA MLLs will be presented. One of them is Compton microscopy at very high photon energies [6-7], which is especially interesting for high resolution imaging of biological samples. However, our MLLs were also used to focus X-ray Free Electron Laser (XFEL) pulses [8] to image sub-micron crystals via convergent beam crystallography [9].

**References**

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