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X-ray Free Electron Lasers: the New Frontier of Spectromicroscopy

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Many decades after the theoretical proposal of x-ray free electron lasers (X-FELs) and after solving formidable technical problems, the first machines of this class were commissioned, first in Stanford and then in several other places. These sources already have a major impact on microscopy for materials science, the life sciences and technology thanks to their fantastic performances. The peak brightness is larger than that of synchrotron sources by many orders of magnitude, the pulse length points to the femtosecond range and the lateral coherence is unprecedented. Recently, the theoretical notion of seeding also became a reality, delivering excellent time coherence and opening the door to sophisticated time-dependent experiments. We will illustrate these exciting developments by first introducing the basic concepts of the X-FEL operation in very simple terms. Then, we will present a selection of recent microscopy results and briefly discuss the possible future developments.