Ultrafast coherent Transmission Electron Microscopy with a high brightness laser-driven cold field emission source microscope: imaging, diffraction, spectroscopy and holography with ultrashort electron pulses

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The investigation of the physics of nanoscale systems ideally requires atomic spatial resolution and femtosecond time-resolution. Ultrafast Transmission Electron Microscopes (UTEM) combining subpicosecond temporal resolution and nanometer spatial resolution have recently emerged as unique tools with unprecedented spatio-temporal resolutions [1]. However, the performances of the first UTEMs were limited by the brightness of the photocathodes used as ultrafast electron source [2]. In this context, it was soon realized that UTEMs relying on laser-driven electron sources based on nanoscale emitters would overcome this limitation. This was confirmed by the results obtained on the UTEM based on a laser-driven Schottky type electron source developed in Göttingen [3].

We report on the development of an ultrafast Transmission Electron Microscope based on a cold field emission source, which can operate in either DC or ultrafast mode [4]. Electron emission from a tungsten nanotip is triggered by femtosecond laser pulses, which are tightly focused by optical components integrated inside a cold field emission source close to the cathode [4]. The measured brightness is the largest reported so far for UTEMs [5]. Combining this new high brightness source with an injection/Cathodoluminescence system, composed of a parabolic mirror placed above the sample holder, the UTEM can be used to perform time-resolved ultrafast pump-probe TEM experiments. We will show the possibilities of such an instrument for ultrafast imaging, diffraction, electron holography and spectroscopy.

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