Laboratoire Matériaux et Phénomènes Quantiques
Séminaire Général

Development of a high brightness ultrafast Transmission Electron Microscope based on a laser-driven cold field emission source

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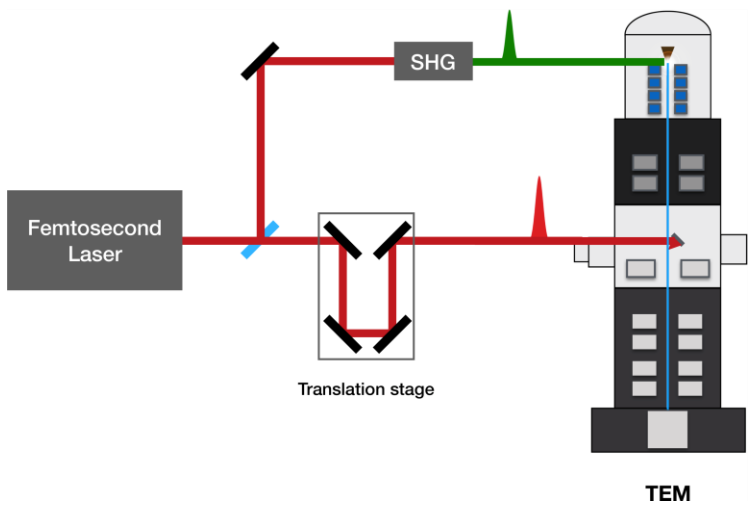
The potential of scientific instruments for materials science is largely governed by the properties of the particle source on which they rely. For instance, in conventional Transmission Electron Microscopy (TEM), it is the superior brightness of cold field emission (CFE) sources which enables the acquisition of electron holograms from which modifications of the phase of the electron wavefunction can be retrieved and traced back to the electrostatic, magnetic or strain fields of the sample. Similarly, the first Ultrafast Transmission Electron Microscopes (UTEM) provided a unique insight into the physics of nano-objects with both sub-picosecond temporal resolution and nanometer scale spatial resolution but could not be used for ultrafast electron holography because of the poor brightness of their electron source [1, 2].

I will describe the development of an ultrafast cold field electron source and its use for Ultrafast Transmission Electron Microscopy [4, 5] first focusing on the instrumental aspects. I will then report on electron energy gain experiments to characterize the spectro-temporal properties of this CFEG-UTEM. The potential of the instrument for conventional imaging, diffraction in parallel and convergent beam, high resolution imaging, electron energy loss spectroscopy and off-axis holography using 150keV ultrashort electron pulses will be illustrated.



Principle of ultrafast TEM: a first laser pulse is sent inside the objective lens of the TEM and initiates the dynamics of the sample. A second, delayed, optical pulse triggers the emission of electron pulses used to investigate the sample at controlled pump-probe delays.

[1] Zewail, A. H., Science, 2010, 328, 187-193
[2] Zewail, A. H., USPTO n°US7,154, 091 of December 26. 2006
[3] A.Feist et al Ultramicroscopy. 176, 63-73, (2017)
[4] G.M. Caruso et al Appl. Phys. Lett. 111, 023101, (2017)
[5] F.Houdellier et al Ultramicroscopy. 186, 128-138, (2018)

Resp. séminaires : Alexandre LE BOITÉ & Damien ALLOYEAU