Ultrafast electron microscopy without photoemission

Gabriele Bongiovanni[1], Mark M. J. van Rijt[1], Ondřej Sháněl[2], and Erik R. Kieft[1]

Ultrafast transmission electron microscopy is an emerging field with the potential to significantly enhance our understanding of nanoscale physical and chemical transformations. Its applications span a broad spectrum, from solid-state physics to biological processes.

Traditionally, ultrafast electron microscopy employs a pump-probe scheme. This method initiates dynamics at the sample with an ultrashort laser pulse, and probes after a specific delay with a photoelectron pulse. While versatile and adaptable to various applications, this method has several drawbacks. The extraction of photoelectron pulses presents technical challenges and the alignment specific to the pulsed mode must be conducted with minimal signal. Most critically, the spatial and temporal coherence of the pulses are typically inferior to those of an electron beam from a field emitter.

In collaboration with TU Eindhoven, we at Thermo Fisher Scientific have pioneered an alternative approach using a resonant RF cavity. This method allows for the generation of pulses of a few hundred femtoseconds at the simple flip of a switch, while maintaining the superior coherence properties of a field emitter. Pump-probe experiments can be executed by electronically synchronising the RF field driving the cavity with an external laser oscillator.

We will present atomic-resolution micrographs acquired with our ultrashort pulses, alongside the results of a series of PINEM experiments. From these, we deduce an instrument response (synchronisation jitter convoluted with electron pulse duration) of a few hundred femtoseconds. These findings underscore the power and potential of RF-based ultrafast electron microscopy as a user-friendly, flexible, and high-coherence electron beam tool.

[1] Thermo Fisher Scientific, Eindhoven, The Netherlands

[2]Thermo Fisher Scientific, Brno, Czech Republic

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