CSU PHYSICS COLLOQUIUM

“Laser-free GHz stroboscopic TEM: construction, deployment, and benchmarking ”

June W. Lau

NIST, Gaithersburg, MD

Monday, Sept. 14th at 4:00pm

Virtual via Zoom (see announcement for link)

Abstract

In the previous two decades, important technological advancements have expanded the range of temporal resolution in transmission electron microscopes (TEM). Commercial direct-counting and single-electron detectors have revealed dynamics in the ms-timescale. Laser-actuated photoemission microscopes [1, 2] combined with beam scanning, spatially-parsed large area detectors [3], and sparse-sensing algorithms [4], can now unlock phenomena at the ms to sub-ps timescales. Further optimization of the photoemission stage [5] and beam bunching technologies could extend the temporal resolution into the deep fs-regime.

Following our earlier concept paper [6], we now present the modifications to a pair of commercial instruments – one Schottky (200 keV) [7] and one thermionic (300 keV) [8] that can confer temporal information spanning the ns and ps range with MHz to GHz repetition rates, in the stroboscopic mode without an excitation laser. The key enabling technology is a pair of broadband phase-matched modulating and demodulating RF pulsers. We have demonstrated 11 ps and 30 ps on the 200 keV and 300 keV microscopes respectively. The placement of the pulsers, mounted immediately below the gun, allows for the preservation of all optical configurations otherwise available to the unmodified instrument, and therefore makes these instruments dual-mode, both stroboscopic time-resolved (strobe) mode and conventional continuous waveform (CW) mode.

To show that the modifications preserved imaging and diffraction functionalities of the instrument, we obtained Au images and diffraction patterns using both a continuous and a strobed beam. We will also show the first proof-of-principle demonstration of these new instruments through images of RF waves moving through an interdigitated MEMS device. In addition to using these beam pulsers for temporally-resolved microscopy, we have evidence showing that they can be effective dose-rate management devices for beam-sensitive materials such as polymer and biological samples.

Team Members: Karl B. Schliep, Michael B. Katz, Vikrant J. Gokhale, and Jason J. Gorman, Ao Liu, Yubin Zhao, Hyeokmin Choe, Chunguang Jing, Alexei Kanareykin, Xuewen Fu, Yimei Zhu.

Biography

June Lau is a physicist at the NIST Materials Measurement Laboratory in Gaithersburg, where she also did her postdoc. She holds a PhD from Columbia University, and her PhD research was with Yimei Zhu’s electron microscopy group at Brookhaven National Laboratory. She holds two patents and an R&D100 award (December 2019) for her work on “Affordable Laser-free Retrofittable Stroboscopic Solution for Ultra-fast Electron Microscopy”, the subject of this talk. She is also an avid run, reader, and a mom.

[1] VA Lobastov, R Srinivasan, AH. Zewail, Proc. Natl. Acad. Sci. **102** (2005) 7069–7073.

[3] T LaGrange, et. al., Appl. Phys. Lett. **89** (2006) 044105

[3] T LaGrange, BW Reed, DJ. Masiel, MRS Bulletin **40** (2015) 22-28

[4] A Stevens, et al., Advanced Structural and Chemical Imaging **1** (2015).

[5] DA Plemmons and DJ Flannigan, Chemical Physics Letters **683** (2017) 186–192

[6] J Qiu, et. al., Ultramicroscopy **161** (2016) 130.

[7] C Jing, et al., Ultramicroscopy, **207** (2019) 112829.

[8] J. W. Lau, et. al., Rev. Sci. Instr. (*invited article* - in review)