

Photocathode Investigation for Ultrafast Electron Microscopy

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Ultrafast transmission electron microscopes (UEM) have provided scientists the ability to investigate materials dynamics on the nanometer femtosecond spatiotemporal scale, leading to many new scientific discoveries. After starting as highly specialized tools, these instruments are becoming more and more common throughout the world as companies work to make them commercially available and institutions recognize their value. While new operating concepts are being developed [1], typical UEMs in operation utilize a photocathode to produce short bursts of electrons. The community has not coalesced around a single photocathode design, with a variety of geometries and materials being employed [2-4]. While this is partly due to differing needs in terms of coherence, number of electrons per pulse, etc., there is an active field of research trying to determine the best design for photocathodes in UEM, the performance of which is generally the limiting factor in the instruments' resolutions. Here we investigate one such photocathode design, the "guard ring" cathode.

The UEM at the Center for Nanoscale Materials at Argonne is a modified JEOL 2100 plus with a Gatan continuum GIF and a K2 IS detector installed at the end of the spectrometer. The guard ring cathode demonstrated here has a 10 μ m diameter LaB6 crystal embedded in a 500 μ m graphite cylinder. This geometry helps to suppress side emission from the LaB6 and create a more uniform electric field caused by the wehnelt bias [5]. While the cathode behaved as expected upon installation, after a few months of normal operation, emission was also observed from the graphite region, as shown in Figure 1a. After optimization of temporal resolution, it was observed that two separate electron pulses were being emitted from the photocathode, separated by \sim 2.5ps as shown in Figure 1b.

We hypothesize that the emission from the graphite region has to do with surface contamination, specifically surface modification decreasing the work function after cooling from thermionic emission [6]. These findings demonstrate the importance of understanding the photoemission process for UEM photocathodes. Further studies will investigate the change that surface effects have on the photoemission process and how that can affect the UEM performance.

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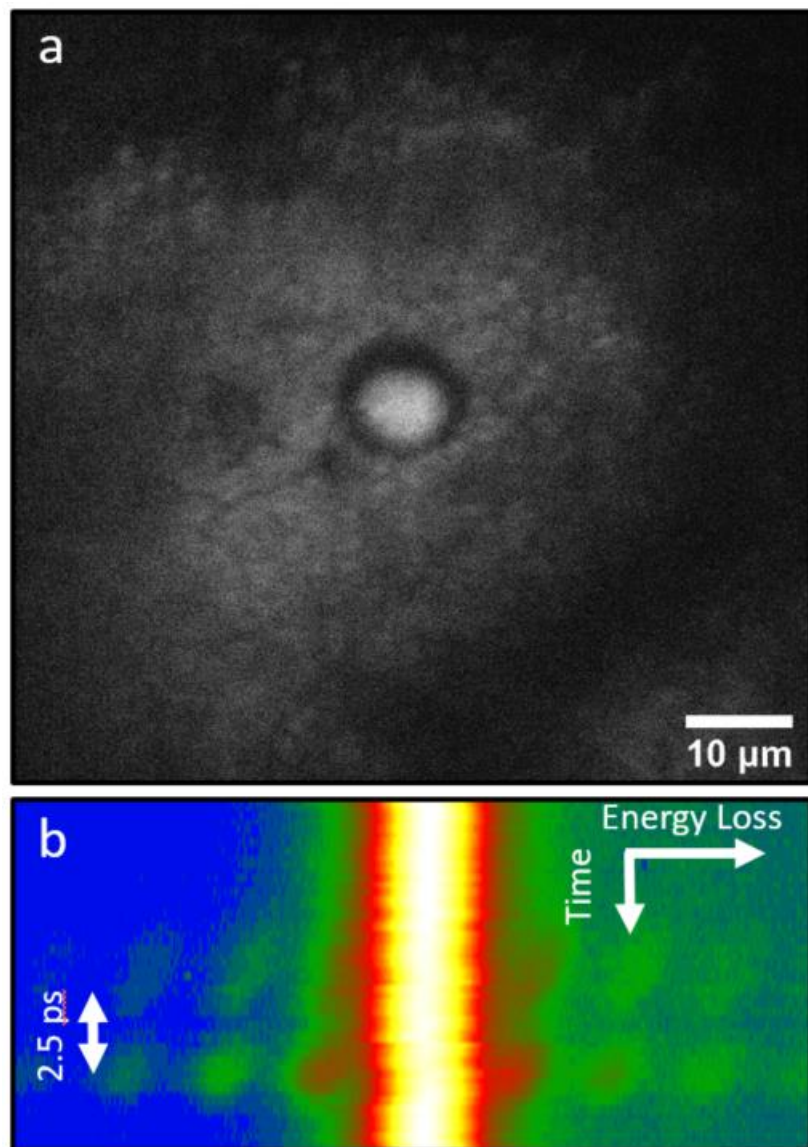


Figure 1. Figure 1. (a) Direct image of the photocathode using photoelectrons showing the LaB6 center surrounded by graphite. (b) PINEM time trace showing the electron pulses separated in time.

References

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