Laser triggered microfabricated Ultrafast Beam Blanker

I.G.C. (Gerward) Weppelman, C.T.H. Heerkens, R.J. Moerland, J.P. Hoogenboom, P. Kruit
Imaging Physics, TU Delft, Lorentzweg 1, 2628 CJ, Delft, The Netherlands, *i.g.c.weppelman@tudelft.nl*

R.F.C. van Tol
DEMO, TU Delft, Mekelweg 4, 2628 CD, Delft, The Netherlands

Femtosecond electron pulses are typically created by illuminating a flat photocathode with femtosecond laser pulses.[1] However, flat photocathodes have a low reduced brightness, 2 orders of magnitude lower than a Schottky electron source. A higher brightness can be achieved using a cold field emitter illuminated with femtosecond laser pulses.[2] Using a cold field emitter illuminated with UV pulses the group of Zewail has realized an ultrafast SEM.[3] However, such an USEM will have the disadvantage that it cannot easily be switched back to continuous beam operation. In addition, the pulse has to be accelerated from the tip onwards which leads to a broadened pulse at the sample.
Here, we propose a beam blanker for use in regular EMs that allows switching between continuous-beam and ultrafast modes of operation. Previous approaches to ultrafast beam blanking were based on beam blankers using GHz magnetic or electric fields.[4,5] This leads to additional energy spread and blurring due to the relatively long transit time through the deflection field.
We will use a miniaturized beam blanker controlled by a photoconductive switch, illuminated with femtosecond laser pulses, as schematically depicted in Figure 1. Hence, the blanker is locked jitter-free to the laser. We fabricated and integrated the deflector plates and the photoconductive switch in one micrometer-scale device, see Figure 2. We will show fabrication results of the ultrafast blanker and its incorporation on an insert for a FEI Quanta FEG 200 SEM. We will also show alignment of both laser and electron beam on the ultrafast beam blanker. COMSOL simulation results, including the full blanker design, are used to evaluate the time response of the system. Finally, we will discuss our plans to operate such an ultrafast SEM in combination with an integrated light and electron microscope (SECOM).[7]

1. **Zewail AH**. Four-dimensional electron microscopy. *Science* 328: 187–93, 2010.
2. **Hommelhoff P, Sortais Y, Aghajani-Talesh A, Kasevich M a.** Field Emission Tip as a Nanometer Source of Free Electron Femtosecond Pulses. *Phys Rev Lett* 96: 077401, 2006.
3. **Yang D-S, Mohammed OF, Zewail AH**. Scanning ultrafast electron microscopy. *Proc Natl Acad Sci U S A* 107: 14993–8, 2010.
4. **Ura K, Fujioka H, Hosokawa T**. Picosecond Pulse Stroboscopic Scanning Electron Microscope. *J Electron Microsc (Tokyo)* 27: 247–252, 1978.
5. **Lassise A, Mutsaers PHA, Luiten OJ**. Compact, low power radio frequency cavity for femtosecond electron microscopy. *Rev Sci Instrum* 83: 043705, 2012.
7. **Zonnevylle AC, Van Tol RFC, Liv N, Narvaez AC, Effting APJ, Kruit P, Hoogenboom JP**. Integration of a high-NA light microscope in a scanning electron microscope. *J Microsc* 252: 58–70, 2013.

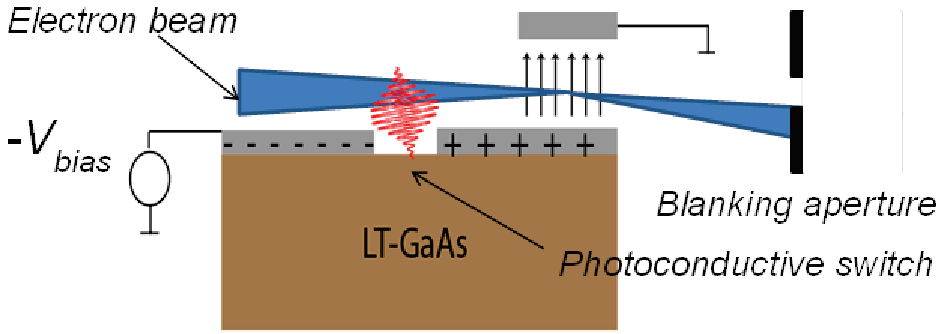

Figure 1: Schematic of the ultrafast beam blanker: A photoconductive switch drives a beam blanker, and this blanker sweeps the electron beam over an aperture to create an ultrafast electron pulse.

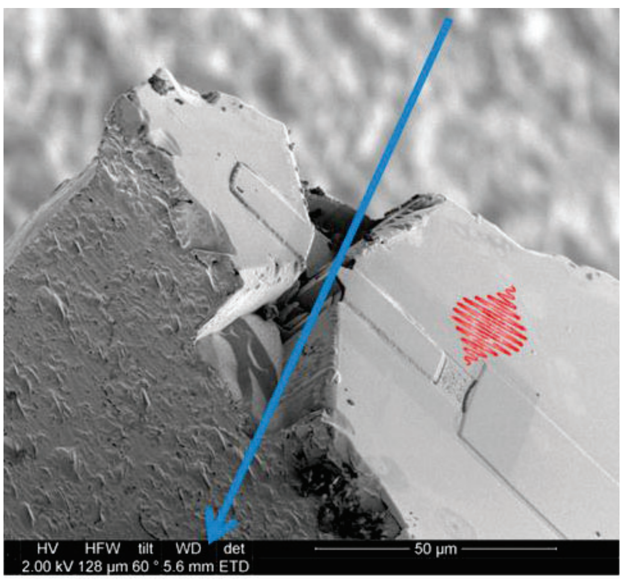

Figure 2: Fabrication result of the proposed ultrafast beam blanker. The blue arrow indicates the trajectory of the electron beam. The red laser pulse indicates the position and illumination of the photoconductive switch.