A New Regime of Nanosecond Photoemission from a Schottky Tip

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Nanoscale metallic tips have emerged as sources of electron beams which are highly localized in space and, when triggered by ultrafast laser pulses, in time. Schottky tips are widely used sources of bright and stable electron beams, and laser-triggered electron emission from these tips has been studied with laser pulse durations ranging from microseconds [1] to femtoseconds [2] for prospective applications in ultrafast electron diffraction experiments and recently multi-pass transmission electron microscopy [3]. Photoemission induced by nanosecond laser pulses is relatively unexplored and could provide coherent electron pulses with limited Coulomb broadening. Recent work from our group explored photo-assisted thermally enhanced field emission from a Schottky tip illuminated by nanosecond laser pulses [4].

Here, we report on a different regime of nanosecond photoemission from a 540 nm ZrO/W Schottky tip. Continuous electron emission is turned off by cooling the tip to 1300 K, and photoemission is triggered by 1 ns pulses from a 532 nm laser. We measure the energy spread of the continuous electron beam and the photoemitted pulses by dispersing the electrons with a magnetic prism array, and we find that the photoemitted pulses have energy distributions broader by 0.5 eV or more. The energy spread of the pulses narrows slightly with decreasing laser pulse energy, so this broadening is attributed to Coulomb interactions. We also find that the total photocurrent has a linear dependence on the laser intensity, and our measurements of the photocurrent as a function of the angle between the laser polarization and the tip axis are well fit by a $\cos^{2n}(\theta)$ function with $n = 1.36$ (Figure 1). This suggests that the absorption of single photons is sufficient for over-the-barrier emission, and we call this the Schottky-enhanced photoemission regime. Finally, we have characterized the promptness of electron emission, measuring the electron pulse to be emitted within a few ns of the laser trigger. These measurements lay the groundwork for studying single-electron-per-pulse operation in the Schottky-enhanced photoemission regime for use in a future multi-pass transmission electron microscope.

References

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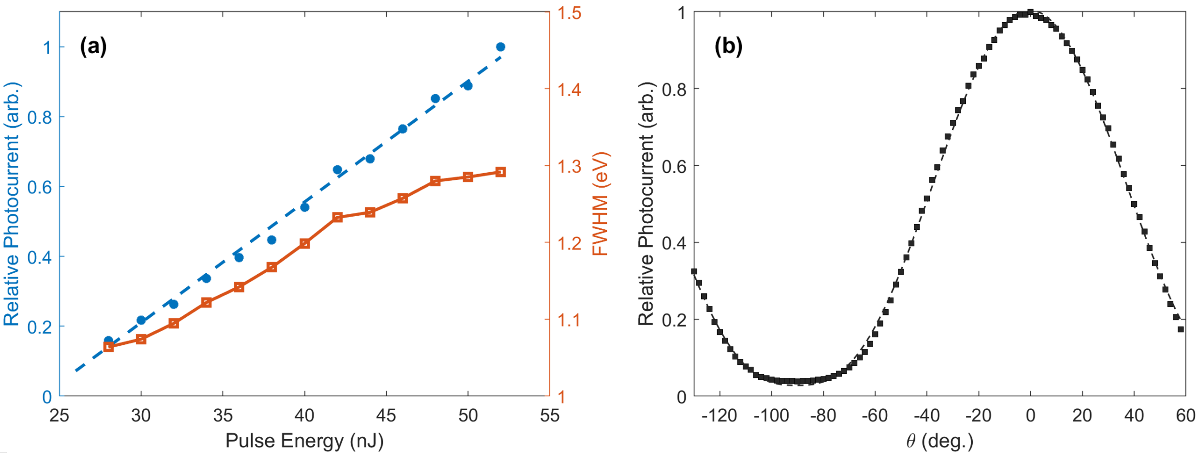

Figure 1: **(a)** Relative electron pulse photocurrent for increasing laser pulse energies. The dashed line is a linear fit. The FWHM of the pulses' energy distributions also increase with increasing laser pulse energy. **(b)** Relative photocurrent for the angle θ between the laser polarization and the Schottky tip. The dashed line is a fit of the form $\cos^{2n}(\theta)$ with $n = 1.36$.