Title: High Aspect Ratio Si Photoelectron Emitter Arrays

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Abstract:

We present experimental results and discuss photoelectron emission from an arrays of high aspect ratio, sharp Si emitters. The structures are prepared from highly doped single-crystal silicon having a pencil-like shape with end radii of curvature of around 10 nm. The tips were illuminated at a grazing incidence of roughly 84º with a 1 kHz titanium sapphire laser beam having a center wavelength of 800 nm, and a pulse duration of 35 fs.

At lower pulse energies (hundreds of nJ) and electron yields, the Si tips, still coated with native oxide, were characterized using a time of flight (TOF) electron energy spectrometer. This revealed an annealing process occurring when the tips were exposed to higher pulse energies (greater than 1 μJ), resulting in a red shift of the energy spectra along with an increased electron yield. Furthermore, the energy spectra demonstrate the development of a broad, high-energy plateau that scales with incident pulse energy. These effects are described through a modified Fowler-Nordheim tunneling model that includes a thinning oxide layer along with electron re-scattering from the tip surface.

Electron currents were then studied at higher pulse energies using similar tip structures with minimal native oxide growth on the surface. The tips were exposed to energies exceeding 7 uJ corresponding to a peak intensity of around 3.2×10^{12} W/cm^2. By fixing the incident pulse energy, an increase in current was also observed when increasing the bias potential. At a bias potential of 70 V, a peak total emission of 0.68 pC/bunch, corresponding to around 1.5×10^3 electrons/tip/pulse, was observed.