Focused-ion-beam-milled GaAs nanotip: A semiconducting ultrafast photoemission electron source

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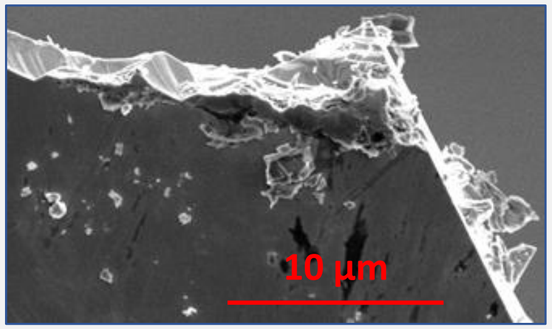
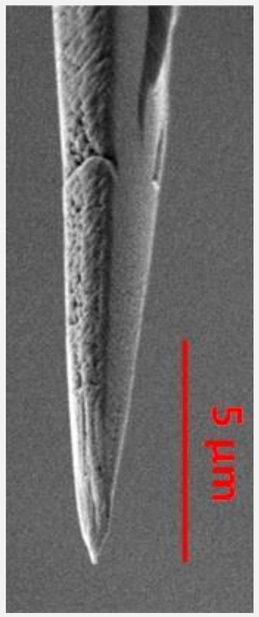
Fig.1 SEM image of a cleaved GaAs shard



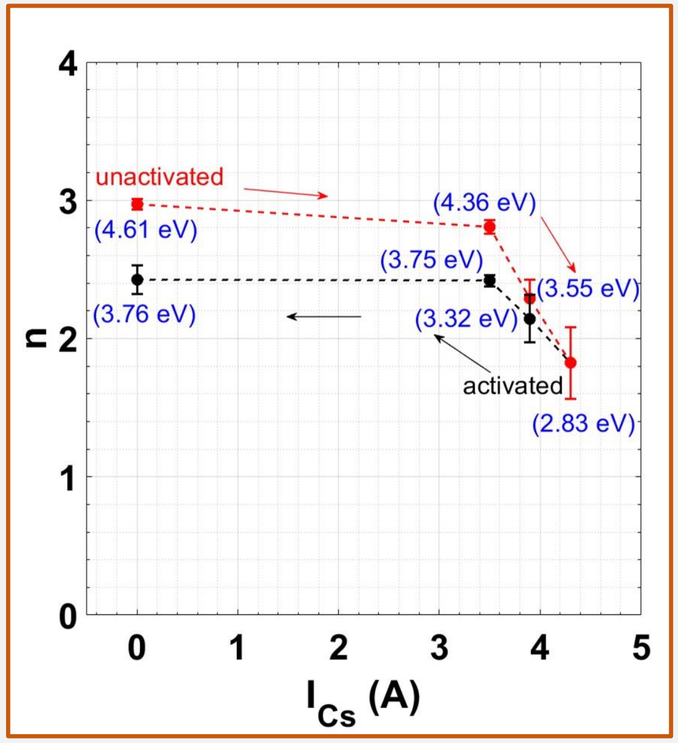
❖ Cleaved GaAs tips contain several sharp (nano)structures which may photoemit under fs laser illumination. We seek to achieve well-defined GaAs nanostructures as ultrafast spin-polarized free electron sources [1-2].

Fig.2 Focused ion beam (FIB) milled GaAs tip



- A nanotip is carved out in a 3D Ga^+ ion milling process (FEI Helios 660). The geometrical apex radius of curvature is 70 nm.
- Femtosecond photoemission properties of this tip are presented.
- We also demonstrate workfunction lowering using a cesium dispenser in the proximity of this tip.

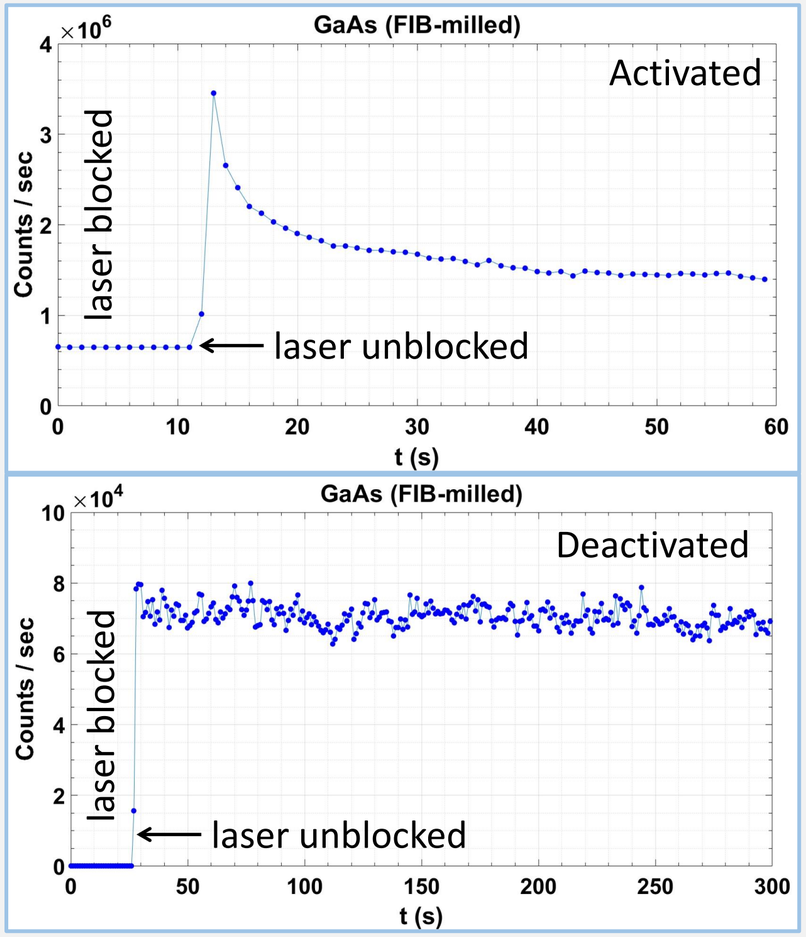
Fig.3 Multiphoton photoemission order varies with the cesiator current



✓ Photoemission order *n* decreases as the deposition rate of Cs on the GaAs tip increases (red data). Ti:Sa oscillator at 90 MHz, <100 fs, 800nm (1.55 eV), <10 GW/cm^2. V_{tip} = -100 V. Workfunction = 4.1 eV.

✓ Activation by Cs decreases the workfunction of GaAs. The total multiphoton energies are shown in parentheses. Large lowered values of up to -1.78 eV for moderate currents are thus demonstrated. Increase in emission current is consistently observed from <2 e/pulse for unactivated tip to up to 8 e/pulse. The tip remains activated (black data).

Fig.4 Count rate stability



✓ The photoemission count rate as well as the emission current off the tip show a transient behavior for the activated tip for the first several seconds after unblocking the laser. We attribute this to fs laser ablation of the deposited Cs layer.

✓ Deactivating the tip by leaving it in the same fs laser focal spot for 6 hours at I_{Cs} = 0 A leaves no Cs for ablation, hence steady photoemission.

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References

[1] E. Brunkow, *et al.*, "Femtosecond-laser-induced spin-polarized electron emission from a GaAs tip", Appl. Phys. Lett. **114**, 073502 (2019).

[2] T.J.Gay, *et al.*, U.S. Patent 1011337, "Fast Spin-Polarized Electron Source."