Optical and Surface Characterization of Alkali-antimonide Photocathodes

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Introduction

- Alkali-antimonide photocathodes, characterized by high quantum efficiency compared to metal cathodes and relatively low mean transverse energy in the visible wavelengths, have emerged as promising candidates for electron sources to drive Energy Recovery Linacs, X-ray Free Electron Lasers etc.

- Although they have been well characterized in terms of QE and MTE, very little is known about their optoelectronic properties, which is critical for understanding the process of photoemission from them.

- Also, brighter beams could be achieved from these films, if the surface non-uniformities are minimized.

- Here, we report on growth of several Cs-Sb cathodes and photoconductivity measurements from Cs-Sb/ SiO2 films. We also present atomic force microscopy and kelvin force probe microscopy measurements to characterize the physical and chemical roughness of Cs-Sb thin films, and try to find out the factors contributing to the roughness.

Growth and QE Spectral Response

- Sources used:

➢ Cs - Cesium molybdate pellets (SAES getter) in an effusion cell

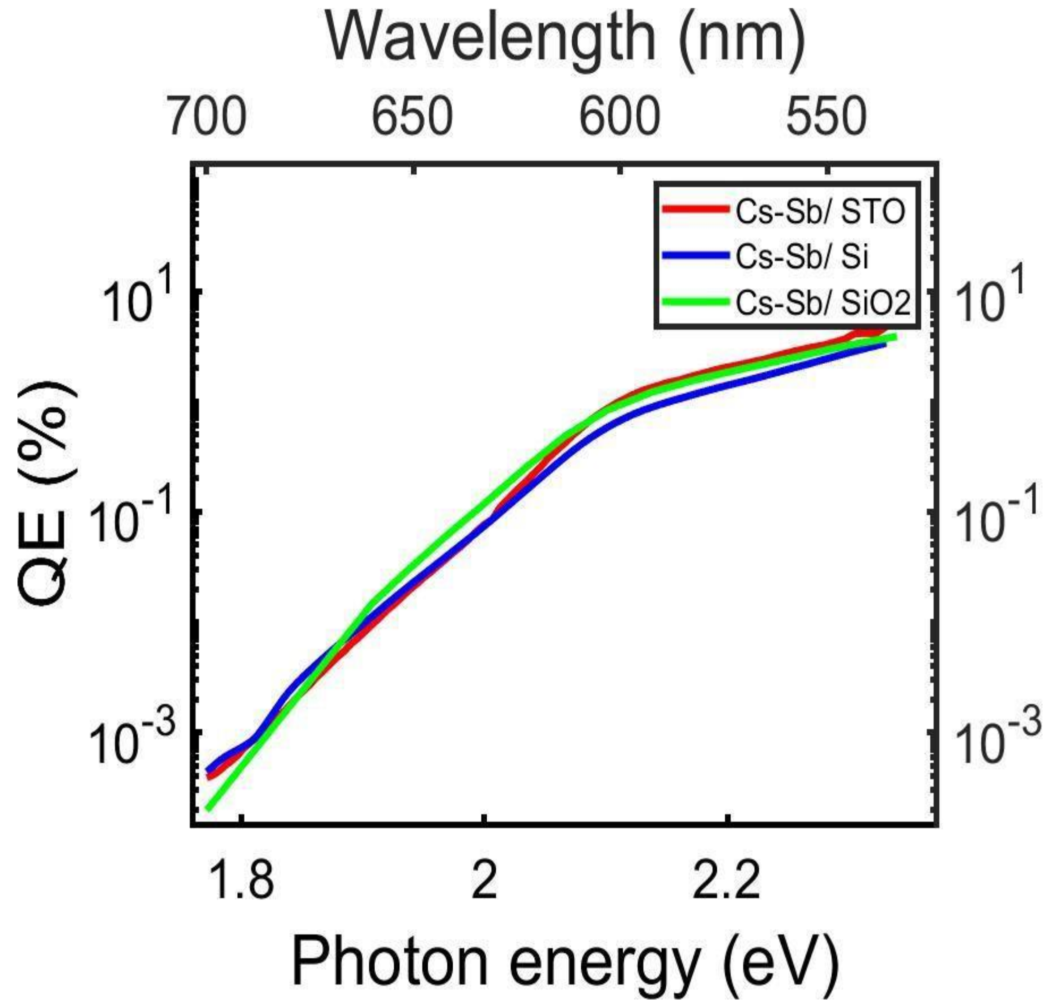
➢ Sb - pure metal in an effusion cell

- Use standard co-deposition technique.

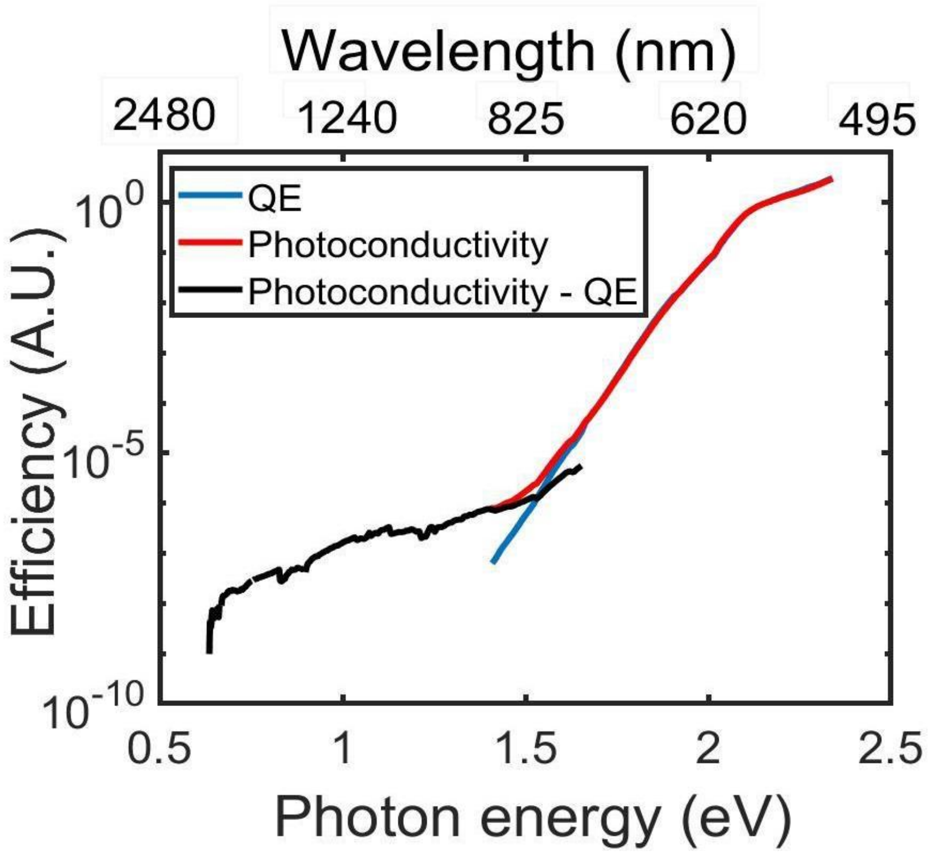
- Monitor Cs pressure in chamber during growth with RGA, Sb flux rate is kept at 0.01 Aº/s.

- Growth is terminated by cooling down both sources simultaneously.

- The photocathodes yield a QE between 3-5 % in green (λ= 532nm).



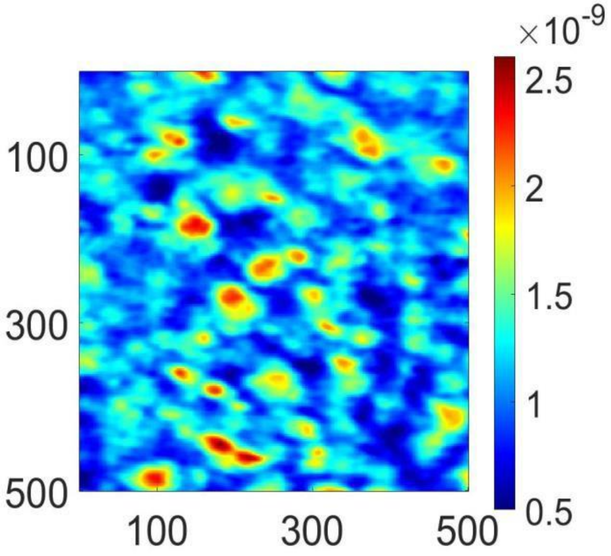
Photoconductivity measurement from Cs-Sb/ SiO_2



- Measured photoconductivity response from film, using an OPA as light source and lock-in amplifier!
- Predicted band gap energy of Cs-Sb photocathodes to be ~0.65 eV!

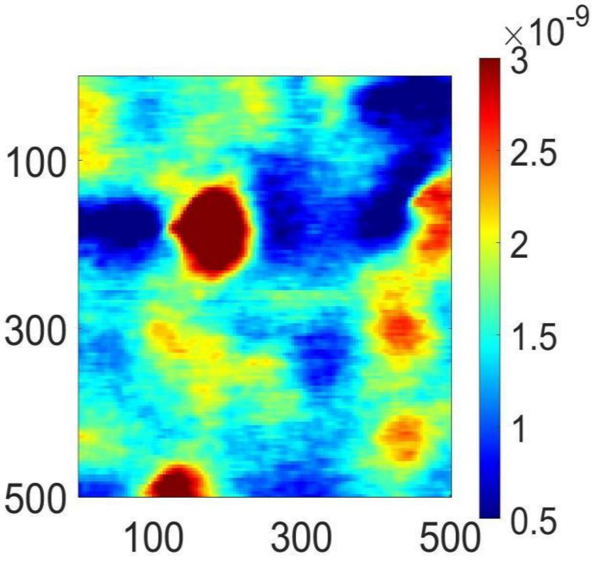
AFM Characterization of Cs-Sb films grown on different substrates

Cs-Sb/ STO_1



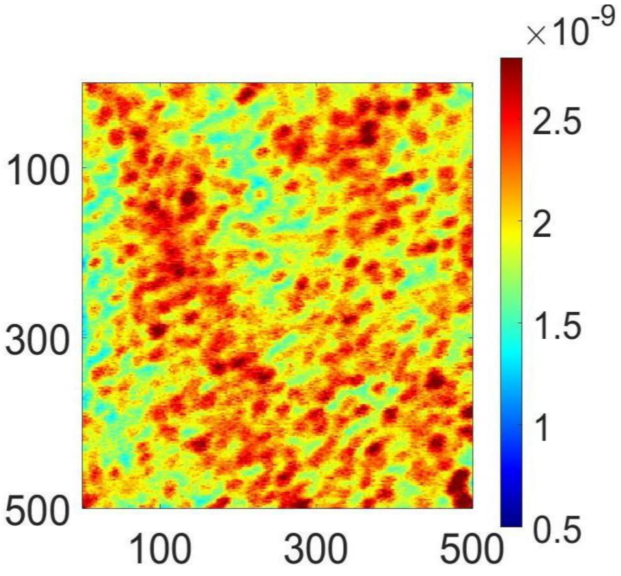
RMS value = 0.31 nm

Cs-Sb/ STO_2



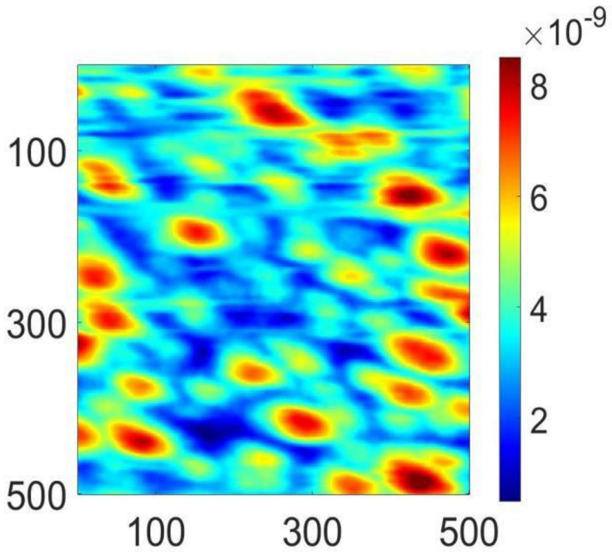
RMS value = 0.57 nm

Cs-Sb/ Si_1



RMS value = 0.32 nm

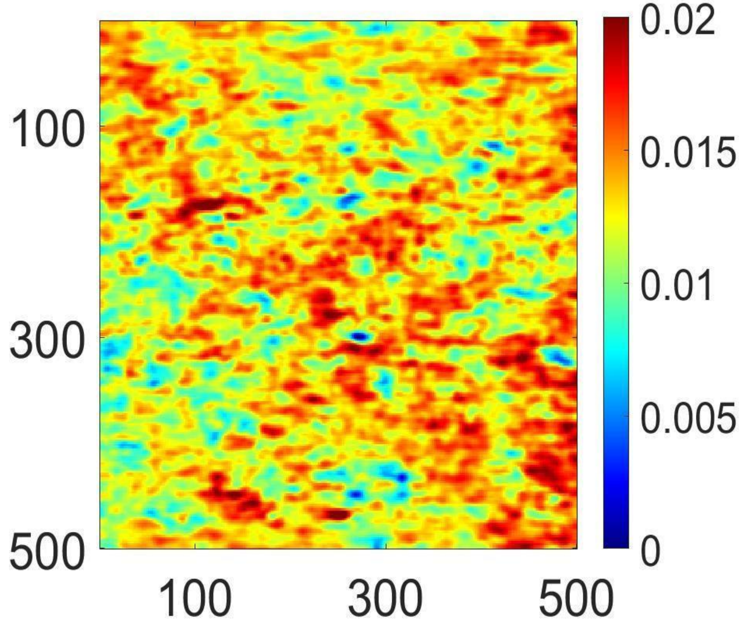
Cs-Sb/ Si_2



RMS value = 1.382 nm

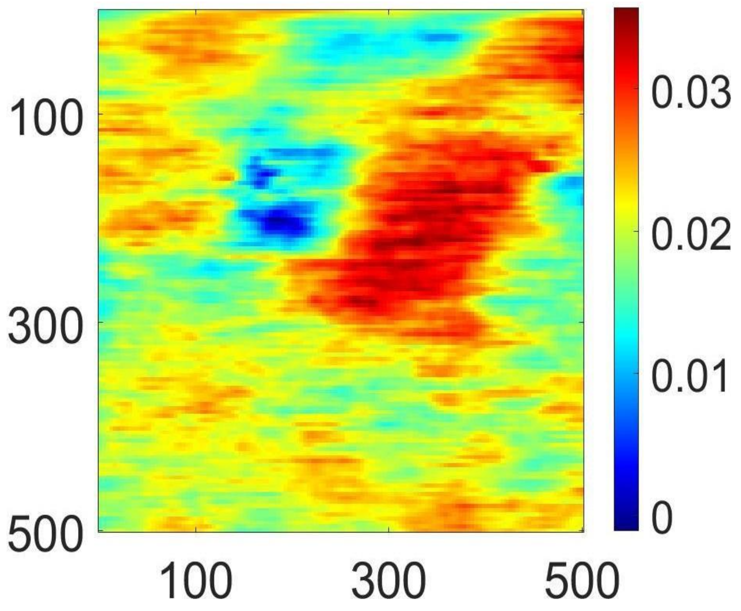
KPFM Characterization of Cs-Sb/ STO

Cs-Sb/ STO_1



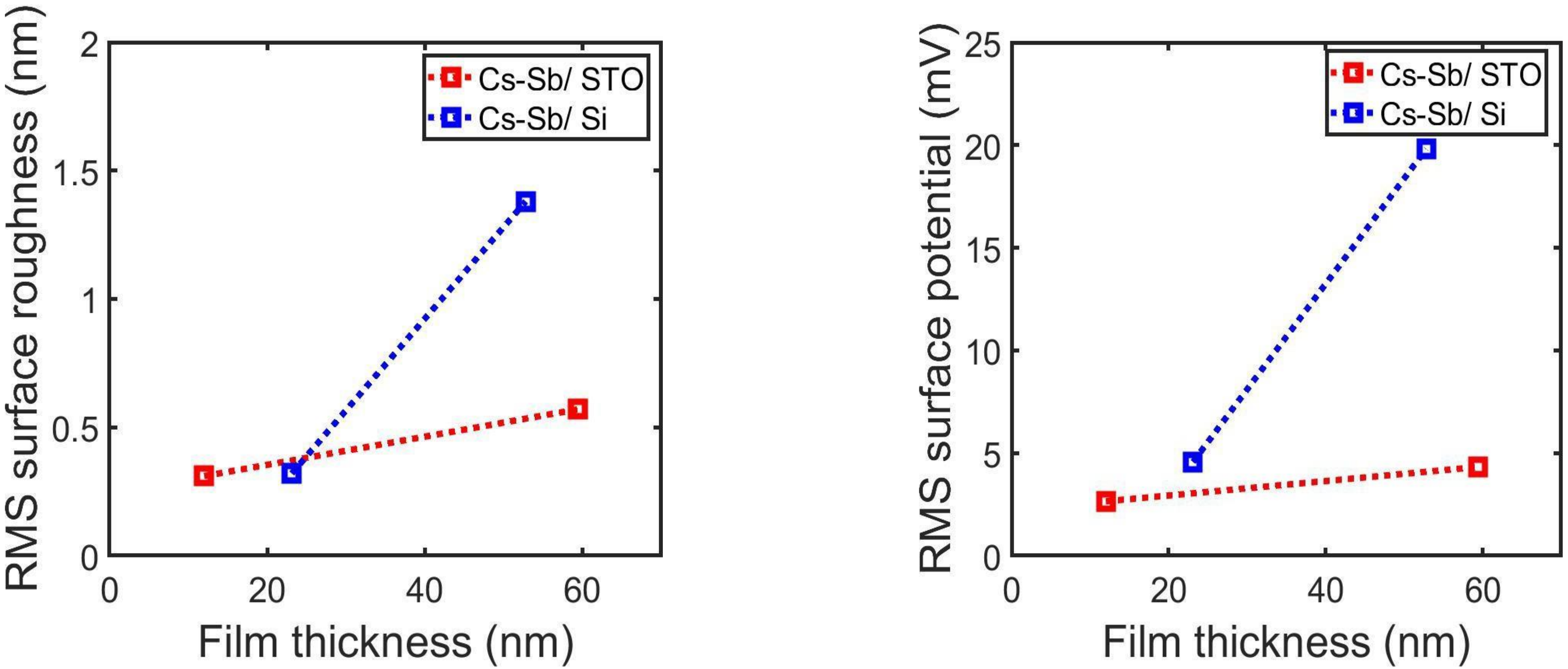
RMS value = 2.65 mV

Cs-Sb/ STO_2



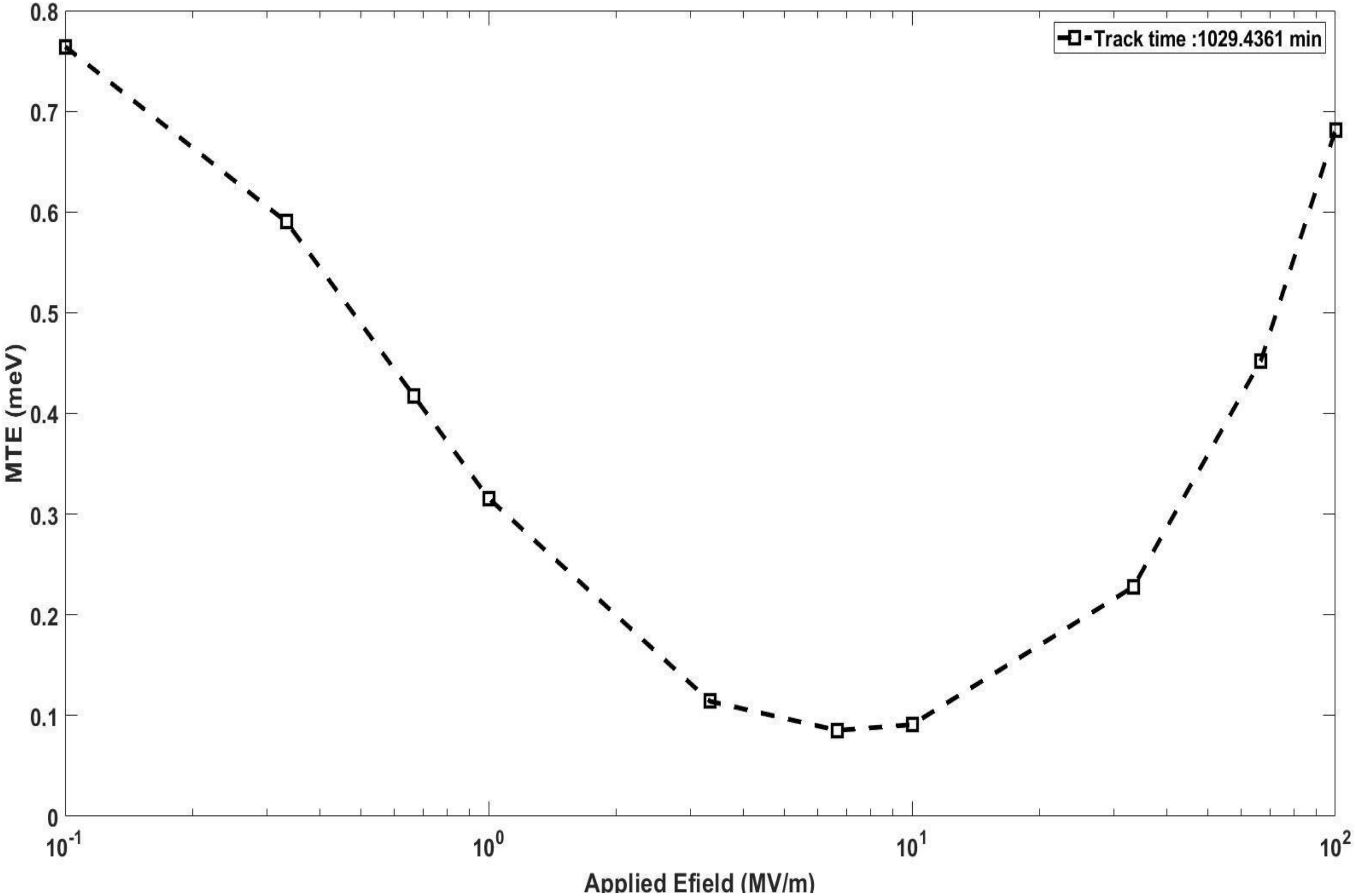
RMS value = 4.32 mV

Surface roughness vs film thickness



The thickness and the substrate plays a big role in the surface roughness of the film. Furthermore, the growth process (thickness, the substrate used and possibly the temperature and the fluxes of Sb/Cs) do have a very big impact on the surface roughness characteristics despite yielding similar QE. Detailed studies of how these parameters impact surface roughness are essential.

Contribution of roughness to MTE from Cs-Sb/ STO



Conclusion

- Based on our photoconductivity measurements, we have predicted the band gap energy of Cs-Sb photocathodes to be around 0.65 eV.

- We have demonstrated the growth of high QE alkali-antimonide photocathodes, with sub-nm physical roughness and ultra-smooth chemical roughness.

- Simulations of the contribution of roughness to MTE from these cathodes, indicate highly promising performance, in low emittance applications.

Future work

Further work is underway to:

(i) to perform photoconductivity studies on films grown on different substrates under different growth conditions, and

(ii) to measure the effect of different growth conditions (fluxes and substrate temperature) on the surface non-uniformities of the cathodes.

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