SURFACE ROUGHNESS MEASUREMENTS OF A Nb (100) PHOTOCATHODE USING STM IMAGING

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The surface characteristics of a photocathode define many important factors of the photoemission, including the intrinsic emittance, the quantum efficiency and the work function of the photocathode.

At STFC Daresbury, Multiprobe (SAPI) [1] is a system which complements ASTeC's Transverse Energy Spread Spectrometer (TESS) [2] and Multi-Alkali deposition chamber (which is under construction) in order to produce and analyse quality photocathodes, by using its multiple R&D facilities including, but not limited to XPS, AFM, LEED and UPS.

The search for a high performance photocathode is a priority in the accelerator science community, as such we present data from Multiprobe, showing STM surface roughness measurements for a Nb (100) photocathode which have been analysed in TESS.

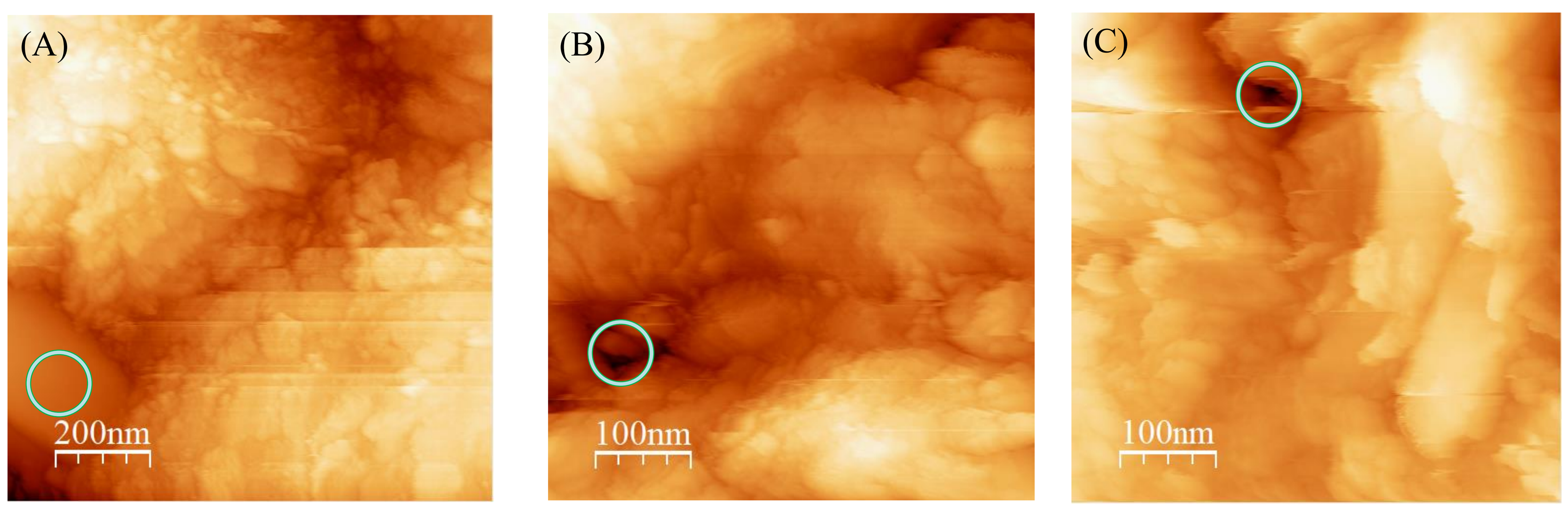

Figure 1: STM images of 3 different locations on the sample surface before spatial corrections - surface defects are indicated by the green circles.

The sample shown in **figure 1** was measured in three different locations (designated as **A, B** and **C**) on the sample surface. As seen, there are a few surface defects which could lead to a difference in the mean transverse energy than what was expected [3].

In each of the sample locations, the scan parameters were set the same – at 400 lines by 400 points with an equivalent scan speed across all three. The scans were run several times and the images presented are those with the least artificial defects shown.

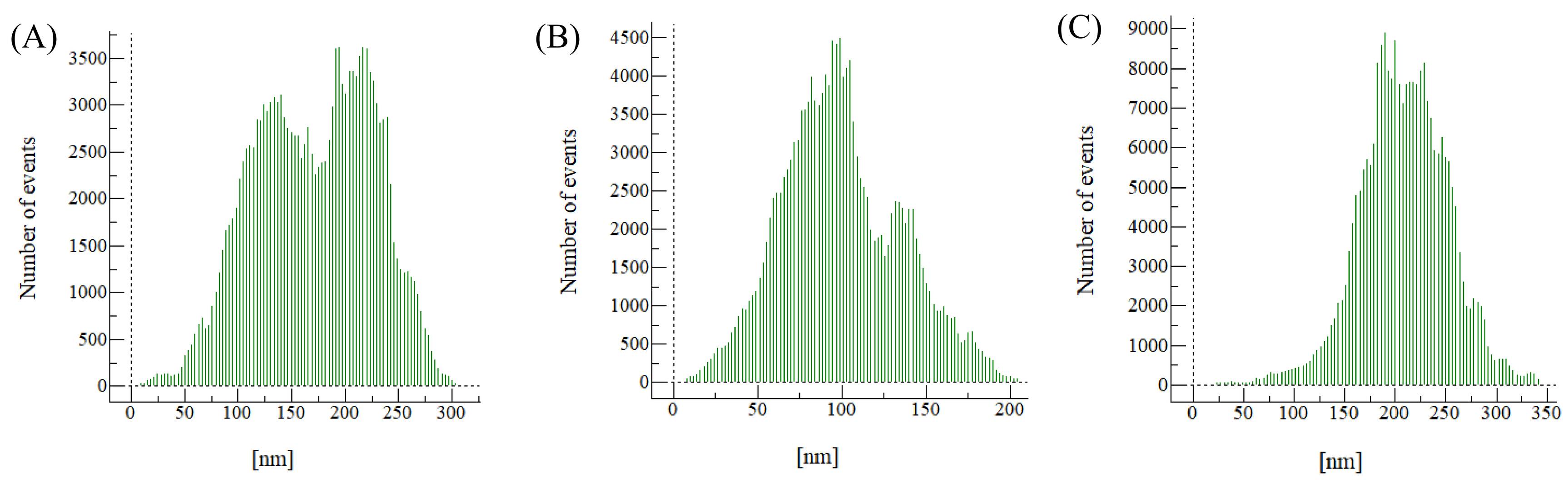

Figure 2: Roughness histograms before corrections of STM images (A), (B) and (C) respectively

Line-by-line spatial corrections were done to the images in **Figure 1** to account for any sudden tunnelling condition changes that may have been produced by the STM tip while scanning the surface of the sample, producing the images in **Figure 3**.

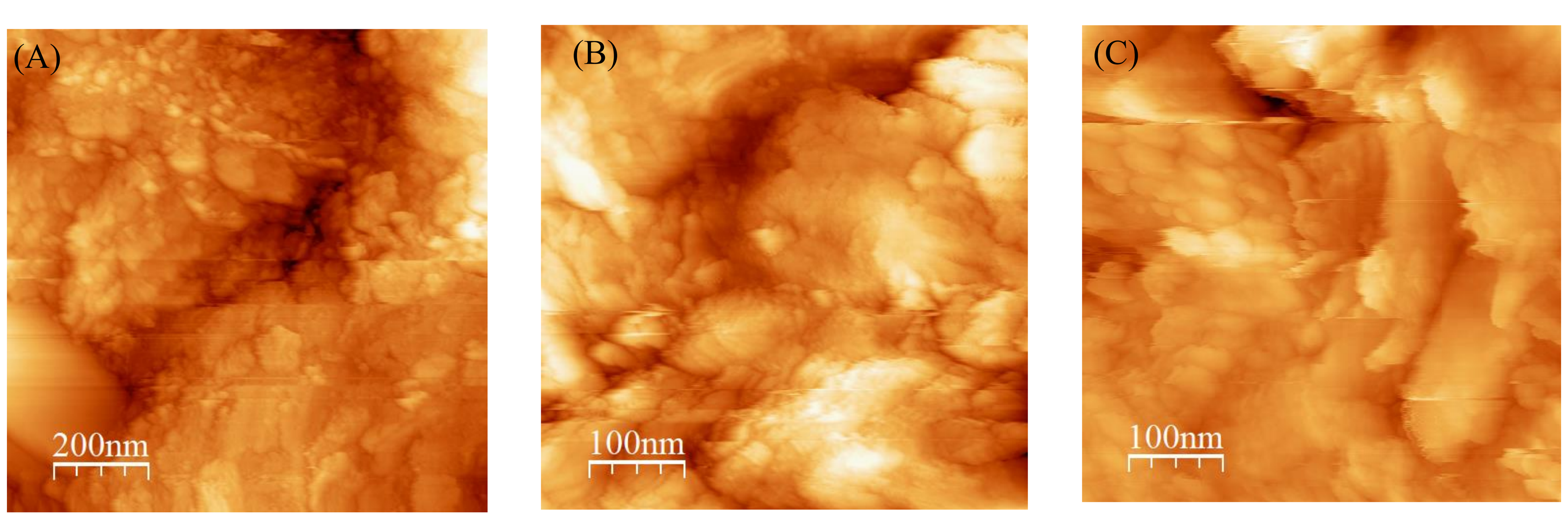

Figure 3: STM images after line-by-line spatial corrections were applied.

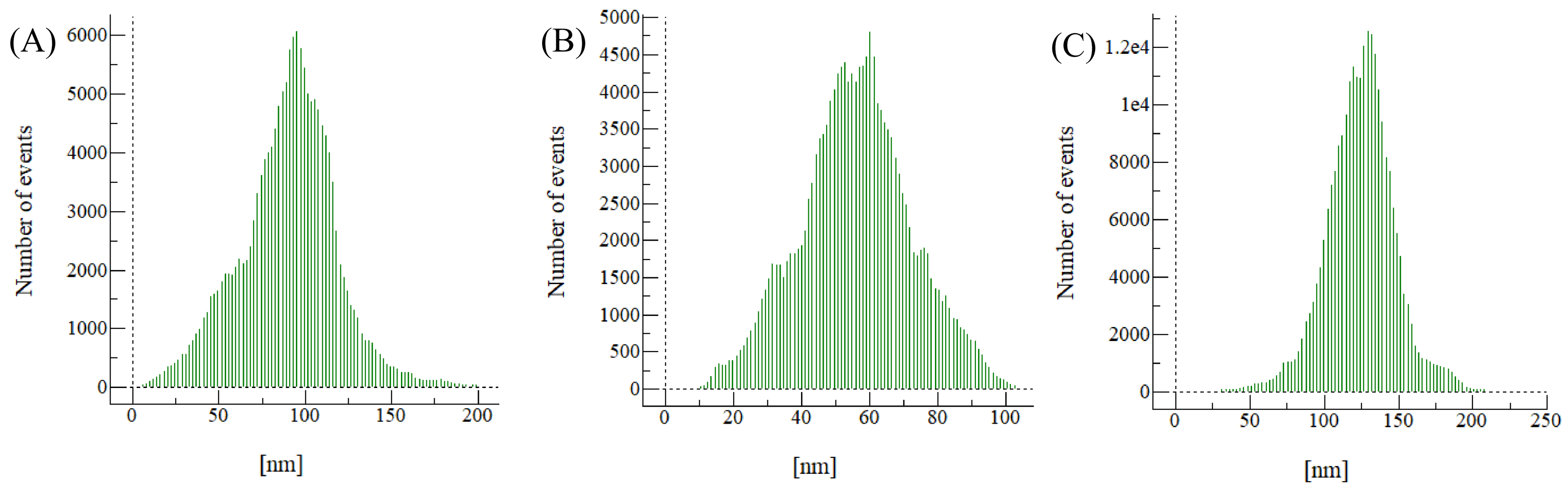

Figure 4: Roughness histograms after line-by-line spatial corrections.

The roughness analysis done to the images in **figure 2** is shown in **table 1** – what this data shows is that across the surface of the Nb (100) sample, the roughness is not completely uniform, fluctuation by a factor of at least 11.57 nm in terms of RMS roughness, and 8.49 nm in terms of mean roughness. The size of this variation can more than likely be attributed to the surface defects seen in **figure 1**. The roughness average of each image varies based on interval range, which for the purposes of these images was set to be 100.

The surface skewness is a measure of the direction of the asymmetry of the distribution of heights in the sample, where a value equals zero is symmetric, a positive value has a positive asymmetry and a negative value is a negative asymmetry [4].

STM Position	RMS Roughness [nm]	Roughness Average [nm]	Surface Skewness [nm]
(A)	27.92	21.44	0.0018
(B)	16.35	12.95	0.0048
(C)	23.75	17.86	-0.1858

Table 1: Roughness analysis of locations (A), (B) and (C)

Overall, the roughness of the Nb (100) photocathode is smooth enough to achieve reliable roughness and MTE measurements. **Figure 4** compliments the data presented, in summary - with a proper control of the surface preparation, the MTE of Nb (100) photocathodes can be decreased at the wavelengths given.

Future work will be done regarding this, including further analysis of the quantum efficiency, as well as analysis via XPS and LEED.

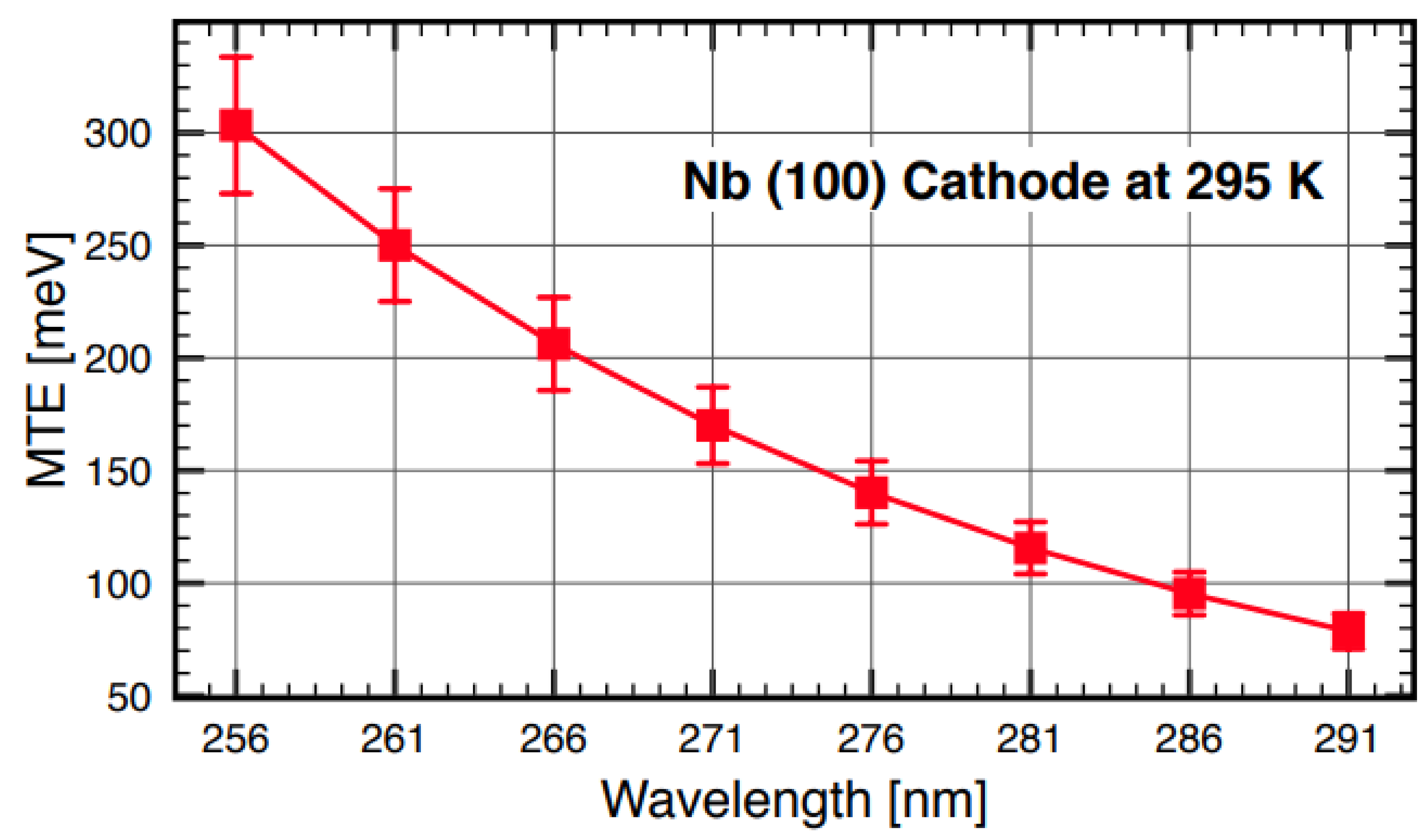

Figure 5: MTE as a function of illumination wavelength for a Nb (100) photocathode

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References:

[1] B.L. Militsyn, 4-th EuCARD2 WP12.5 meeting, Warsaw, 14-15 March 2017

[2] L.B. Jones, K.J. Middleman et al.; Proc. FEL 2013, 290 – 293

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[4] I. Horcas, R. Fernandez, J.M. Gomez-Rodriguez, J. Colchero, J. Gomez-Herrero and A. M. Baro, Rev. Sci. Instrum. 78, 013705 (2007)