

Supporting information

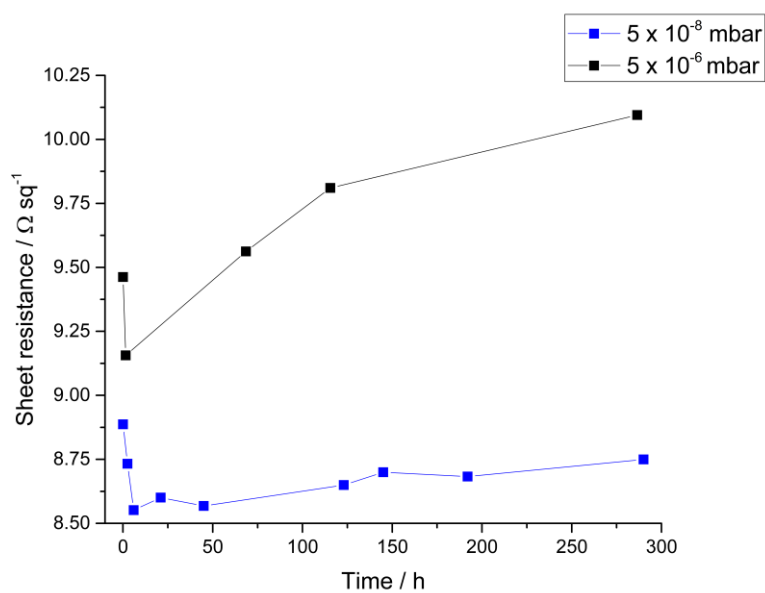


Figure S1. Evolution of the sheet resistance for representative MM | 9 nm Cu | 0.8 nm Al upon exposure to ambient laboratory air, for Cu films evaporated at a base pressure of 5×10^{-6} mbar (black) and 5×10^{-8} mbar (blue). The temperature and humidity fluctuated within the range of 18-30°C and 15-50% respectively.

Table S1. The structures of the electrodes compared in this work. The measurements are made in ambient air and the higher sheet resistance in the MM | Cu electrode reflects that it has already significantly oxidised during testing (< 2 minutes exposure to air).

Abbreviations	Full Structure	Average Sheet Resistance \pm Standard Deviation ($\Omega \text{ sq}^{-1}$) (<i>Champion</i>)
MM Cu	Glass Mixed APTMS:MPTMS monolayer (1:1) 9 nm Cu	10.75 \pm 0.19 (10.54)
MM Cu Al	Glass Mixed APTMS:MPTMS monolayer (1:1) 9 nm Cu 0.8 nm Al	8.69 \pm 0.16 (8.60)
PET MM Cu Al	PET (Plastic) Mixed APTMS:MPTMS monolayer (1:1) 9 nm Cu 0.8 nm Al	9.14 \pm 0.34 (8.80)
Glass Cu	9 nm Cu directly on glass	13.80 \pm 0.64 (13.33)
Glass Cu Al	9 nm Cu 0.8 nm Al directly on glass	9.13 \pm 0.17 (8.96)
PEI Ag*	Glass PEI (spin coated) 9 nm Ag	9.35 \pm 0.32 (9.03)

*Matching $9 \Omega \text{ sq}^{-1}$ reported by Kang *et. al.*⁶

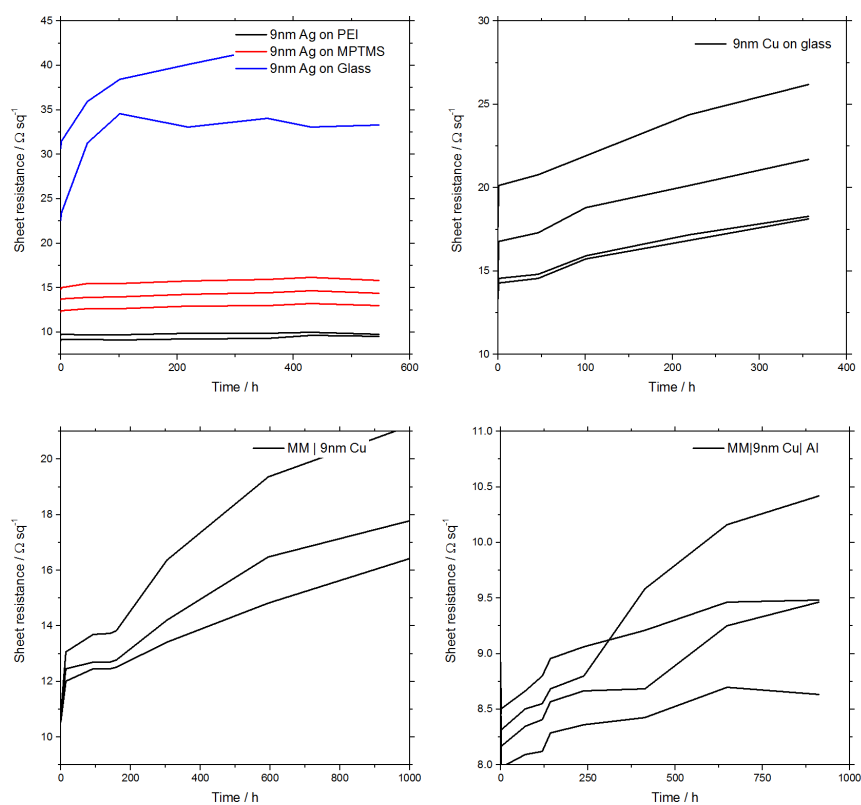


Figure S2: Four graphs showing the complete data sets for the presented electrode structures, see Table S1 for more detail. In Figure 2 only a representative 9nm Ag on PEI was displayed as this was the best performing nucleation layer for Ag in testing.

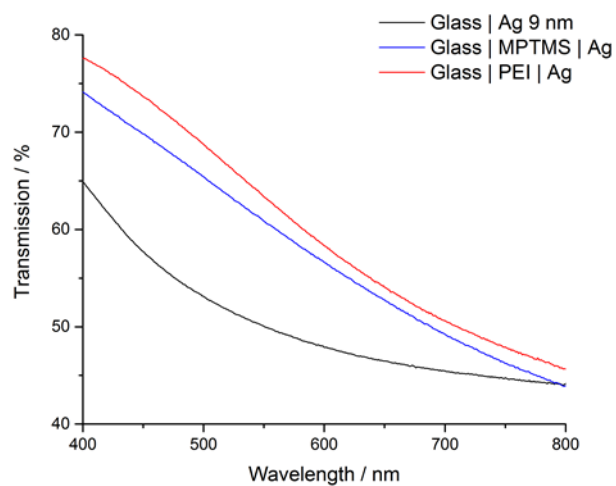


Figure S3: Typical far-field transparency spectra of 9 nm Ag films supported on glass (Black), glass modified with MPTMS (Blue) and PEI (Red) adhesion layers. The Ag was deposited at 1 Å s^{-1} .

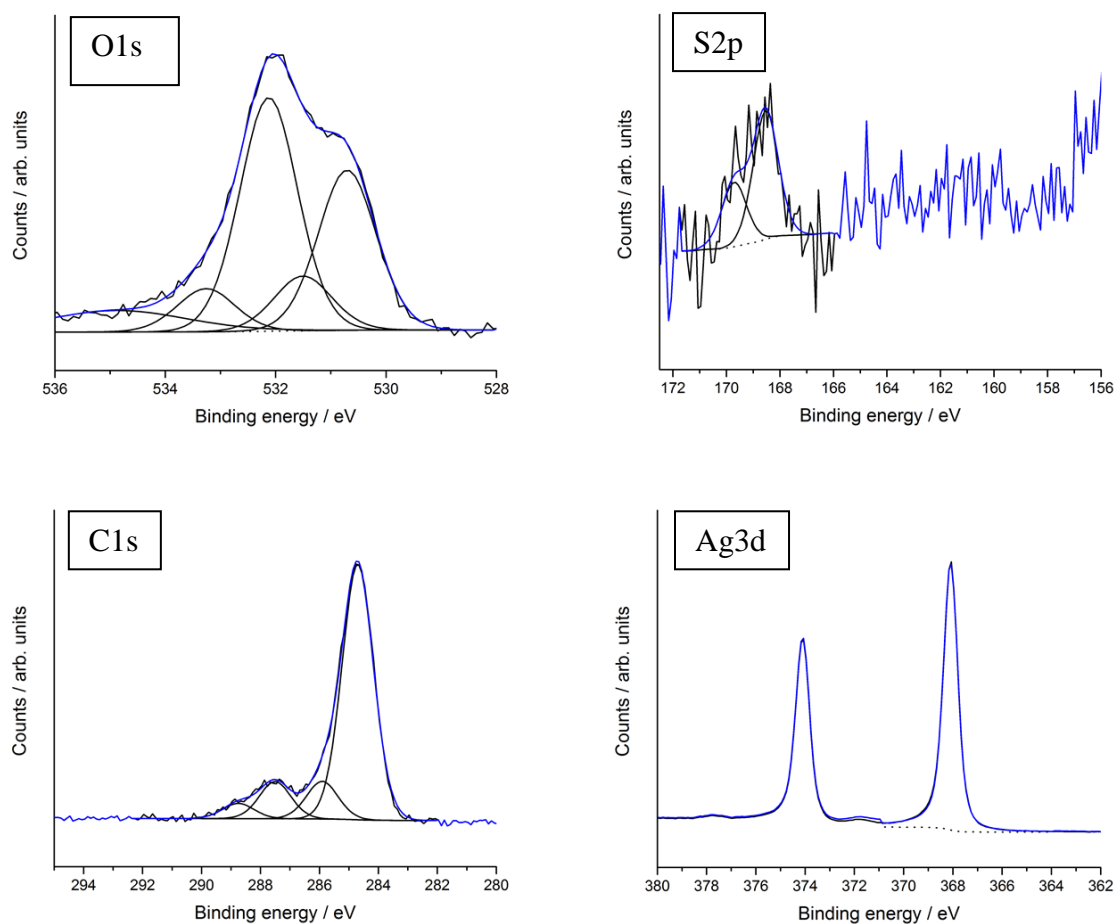


Figure S4: High resolution (HR) XPS spectra for a Glass | PEI | Ag 9 nm electrode aged in air for 2000 hours. The overlap of common products (Ag, Ag₂S, AgCl, Ag₂O, Ag₂SO₄, etc.) in the Ag 3d spectrum prevents fitting (all peaks within 0.4 eV). Tabulated peak positions are given in Table S2.

Table S2: HRXPS peak positions tabulated for the fitted peaks depicted in Figure S4.

Spectra	Peak position / eV	Assignment
O1s	530.7	Ag ₂ CO ₃
	531.5	Ag ₂ SO ₄
	532.1	C-O
	533.3	C-O-H
	534.9	Na KLL
S2p	168.5	Ag ₂ SO ₄ (2p 3/2)
	169.7	Ag ₂ SO ₄ (2p 1/2)
Ag3d	368.1	Ag mixture
C1s	284.7	C-C / C-H
	285.9	C-O-C
	287.5	C=O
	288.8	O=C-O / Ag ₂ CO ₃

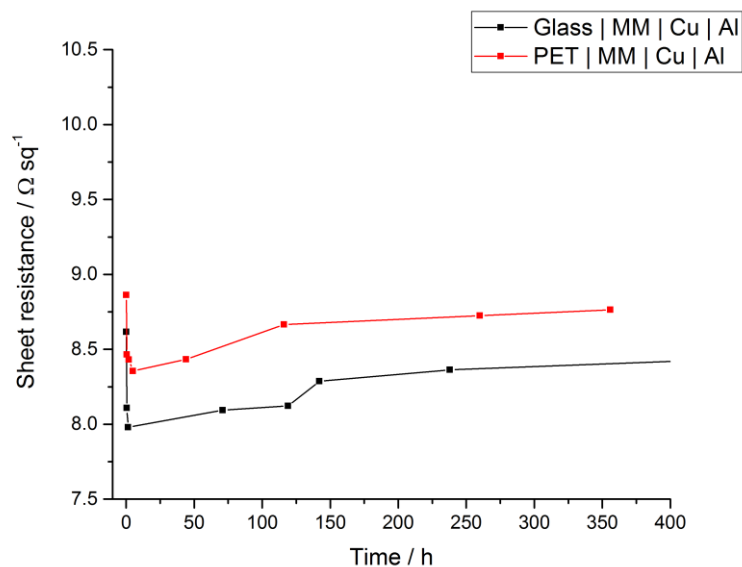


Figure S5. The comparable evolution of the sheet resistance for two representative MM | Cu 9 nm | Al 0.8 nm film electrodes deposited onto flexible PET plastic (red) and glass (black).

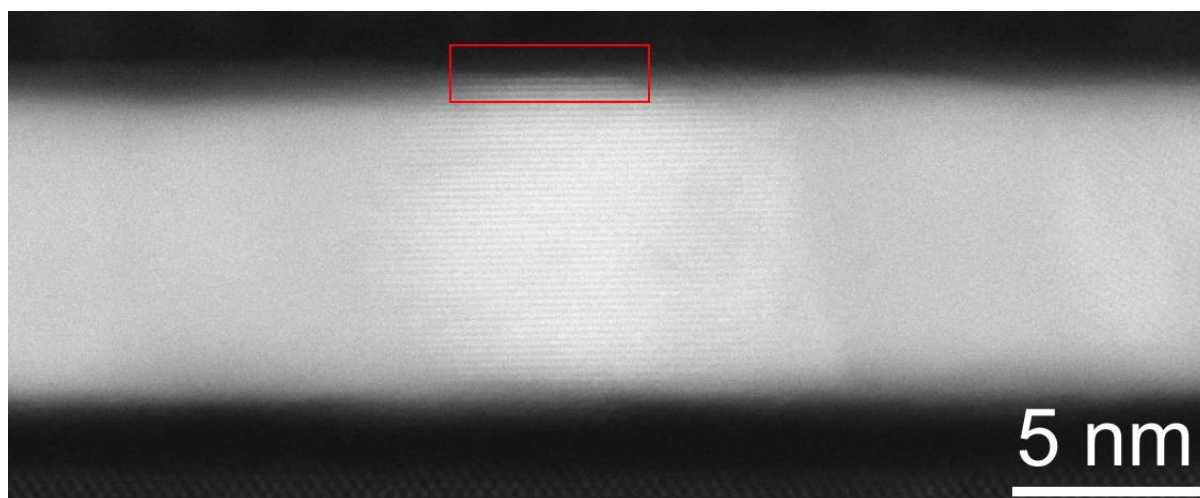


Figure S6: Enlarged region from Figure 1 detailing the surface of the film. The red square highlights the clearest region where a single copper crystallite extends through the entire thickness of the film as deposited. The extension of the lattice fringes to the very surface of the film supports the conclusion that the Al does not remain uniformly distributed but is redistributed across the surface of the film.

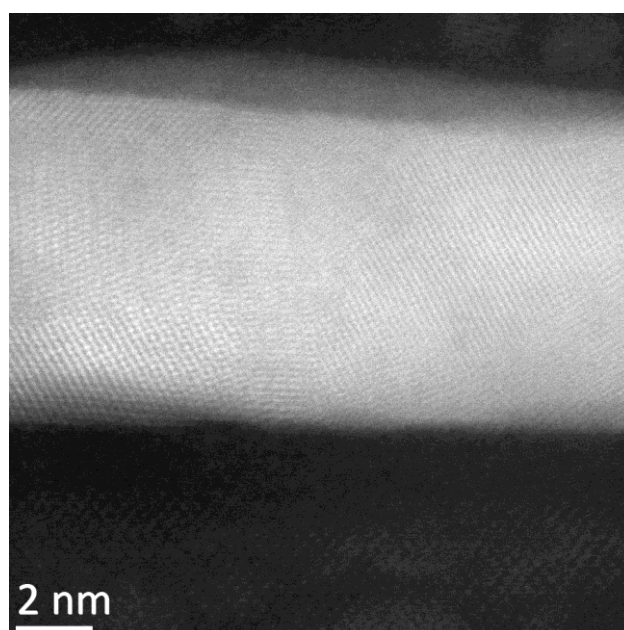


Figure S7: Further high-resolution TEM image of an MM | Cu | Al film, showing the non-uniform distribution of the metal oxide layer over the surface of the film.

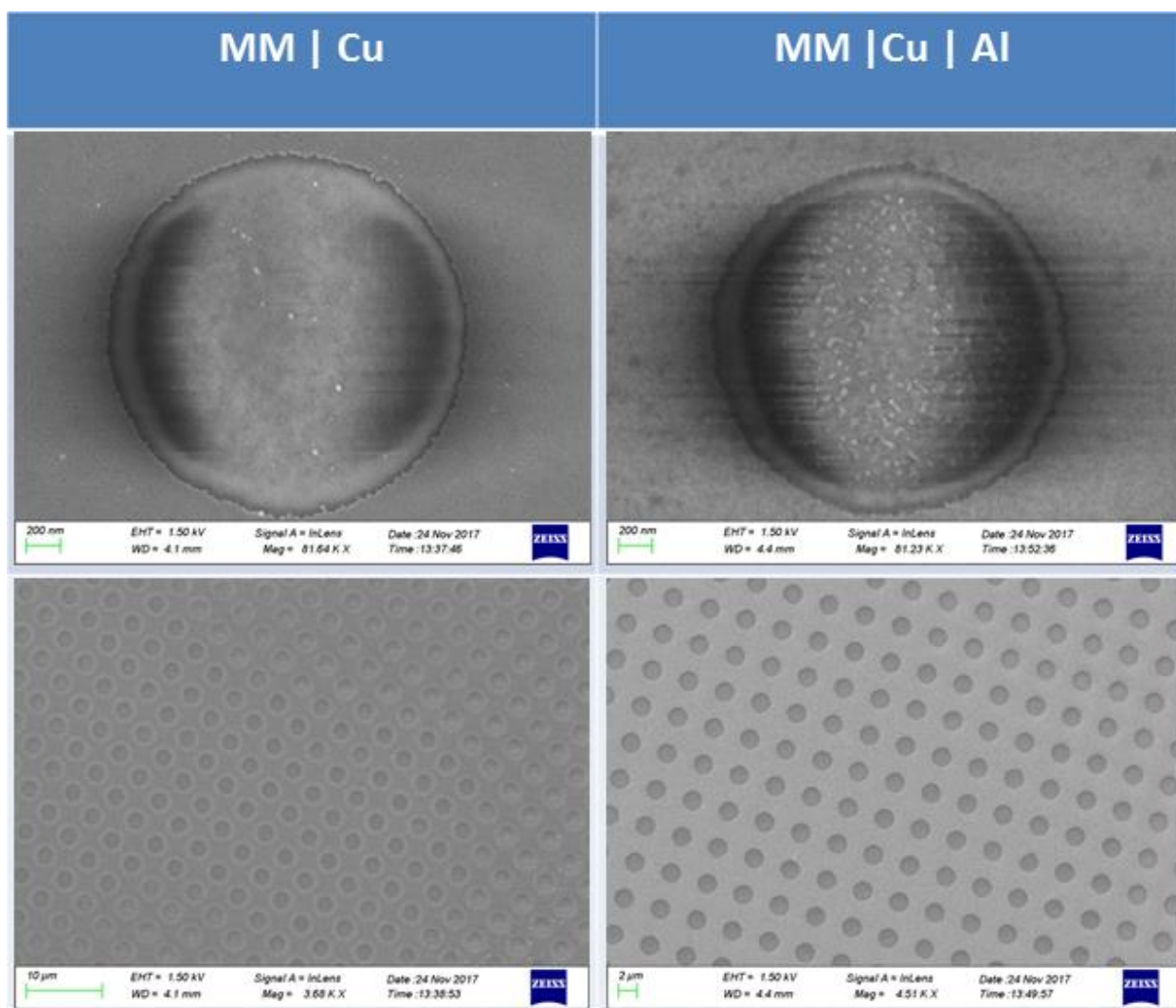


Figure S8: SEM images comparing the size and uniformity of the patterned electrodes produced using a conventional photolithography method and etched using ammonium persulfate solution. At high resolution, when imaging a single aperture, it is clear that the etchant does not cleanly remove the oxidised Al and this debris remains within the aperture which may still contribute to the transparency of the patterned film, especially at > 600 nm (Figure S9).

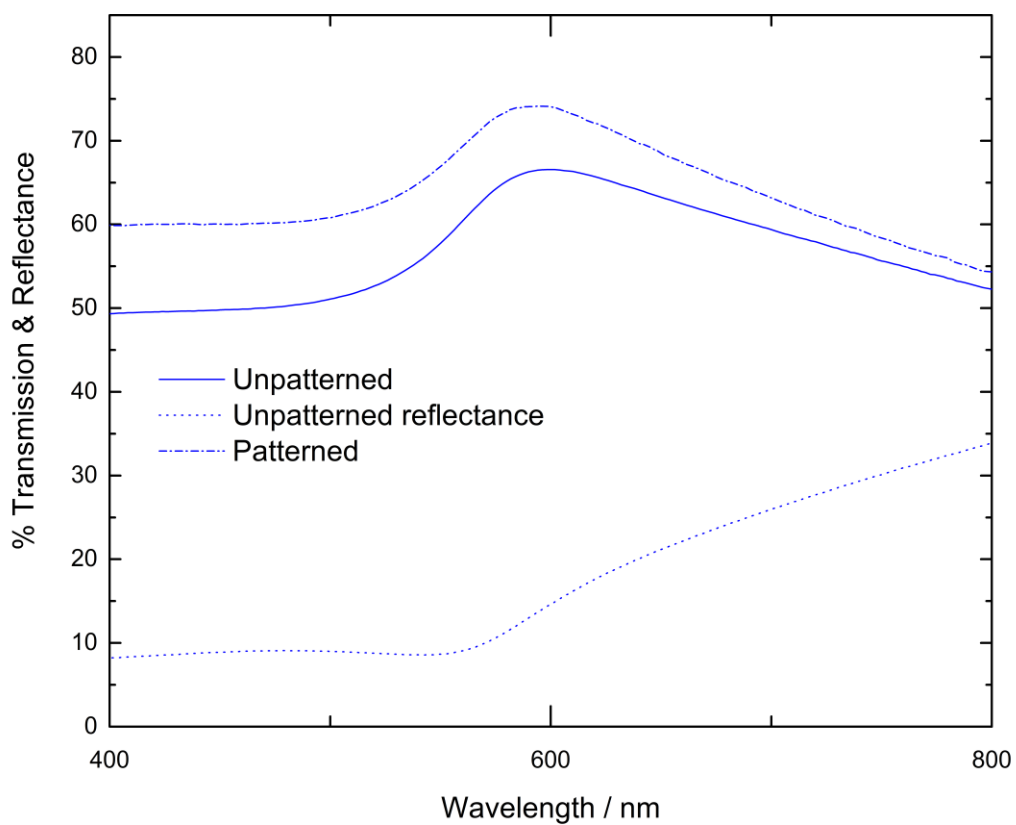


Figure S9: Far-field transparency of the MM | Cu | Al electrode (solid line) and reflectance (dotted) for glass | MM | Cu 9 nm | Al 0.8 nm film electrode. The far-field transparency upon patterning with ~6 million 2 μm diameter apertures per cm^{-2} is also shown (dotted/dashed line).