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MIS Solar Cell Devices based on a Cu_2O Substrate Utilizing h-BN as an Insulating and Passivating Layer

Supplementary Information

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Supporting Information Content

A) Material Characterization

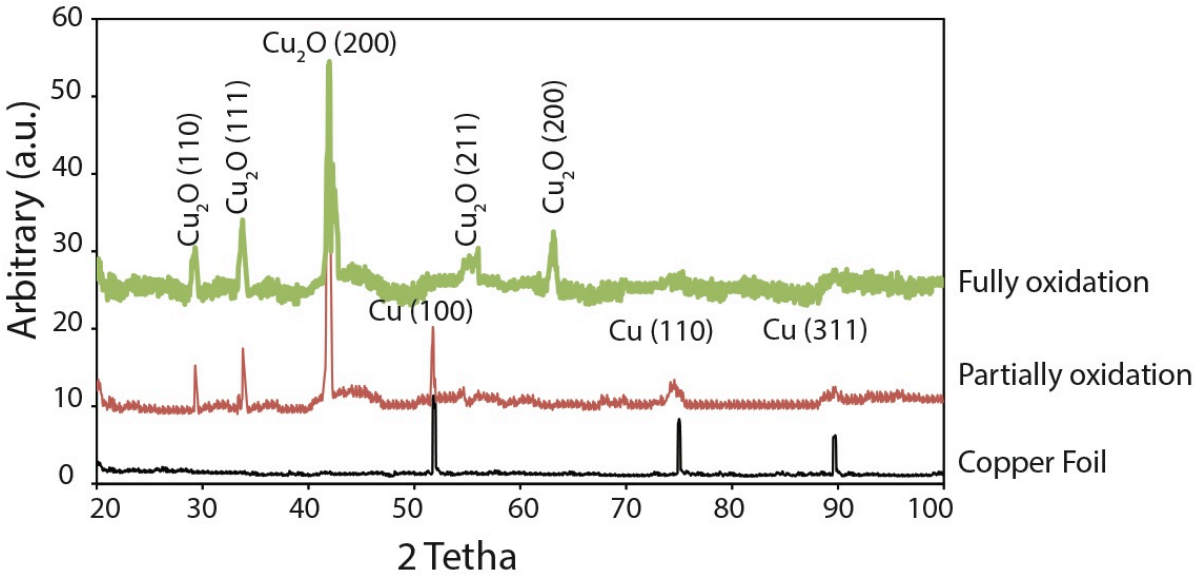

Figure S 1 X-ray diffraction pattern of copper foil , partially oxidized and fully oxidized trends.

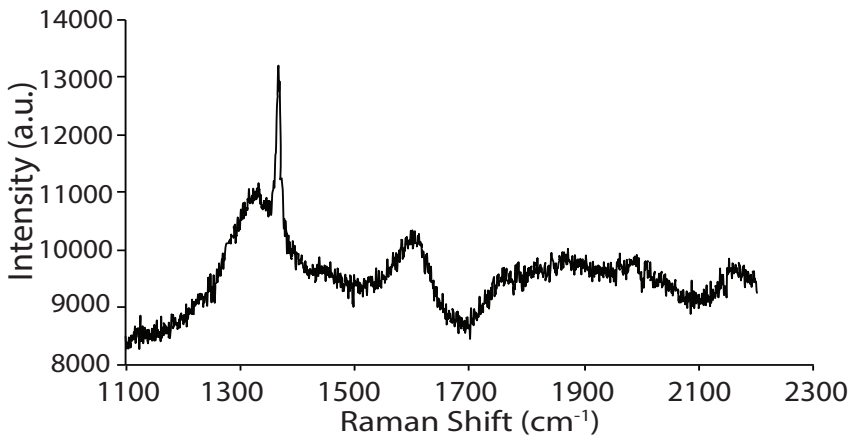

Figure S 2 Raman spectrum of exfoliated h-BN layer which was transferred to a Si/SiO_2 substrate after Cu_2O etching. The signature of B-N vibrational E_{2g} peak of h-BN was observed at 1366.7 cm^{-1}. It shows that h-BN remains intact after Cu_2O growth.

B) Photovoltaic Measurement

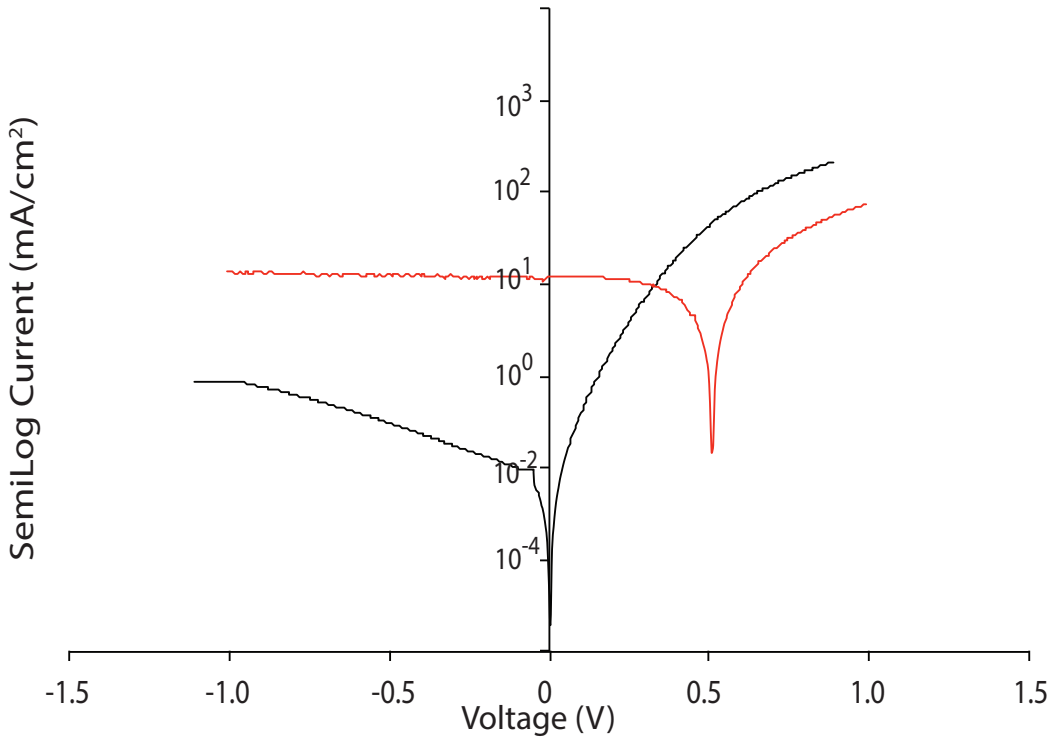

Figure S 3 Semi log plot of I-V curve of 3.44% efficient device structure. Voc 0.52V.

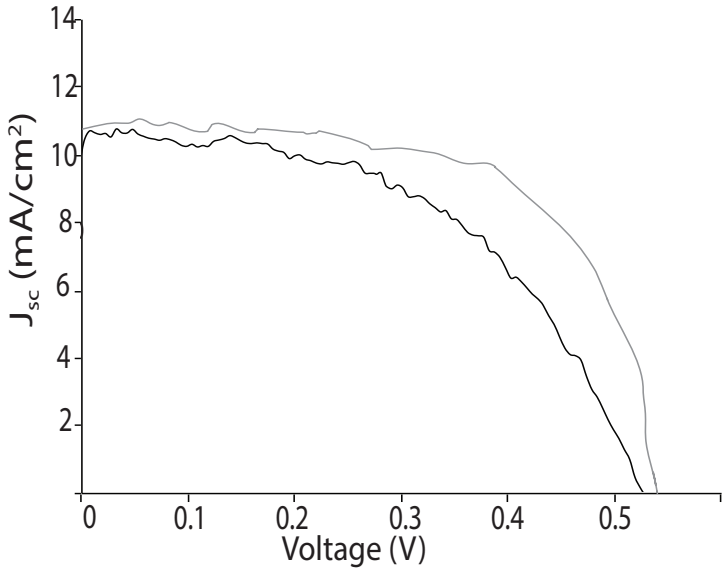

Figure S 4 Measurements of J-V curve of Cu/h-BN/Cu_2O/CuO/Au-Cr sample with slow and fast voltage sweeping rate of transient (gray curve) and steady state (black curve). Fast sweeping rate between data points improves FF and efficiency. Apparent efficiency calculated over 4% for transient state.

C) Electrical Characterization

(a)	Carrier Concentration ($/cm^3$)	Mobility ($cm^2/V\cdot s$)	Resistivity ($\Omega\cdot cm$)(300K)
No BN	5.75×10^{17}	15.78	160.257
O_2 Cooling	4.47×10^{18}	34.29	212.716
N_2 Cooling	3.45×10^{18}	68.66	102.827
H_2 Cooling	8.9×10^{17}	105.73	143.563

Parameters: B=0.6T D=2μm I=0.6mA t=arbitrary

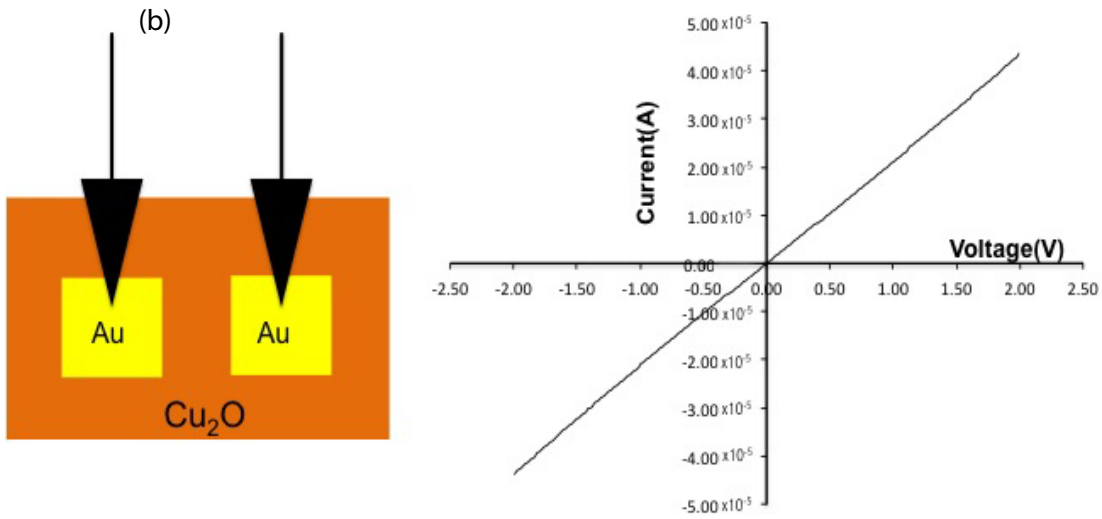

Figure S 5a.)Hall effect measurements on Cu_2O structure formed with introducing different cooling gases b.) Ohmic contact behaviour is shown on IV curve of Au/Cu_2O/Au Junction.

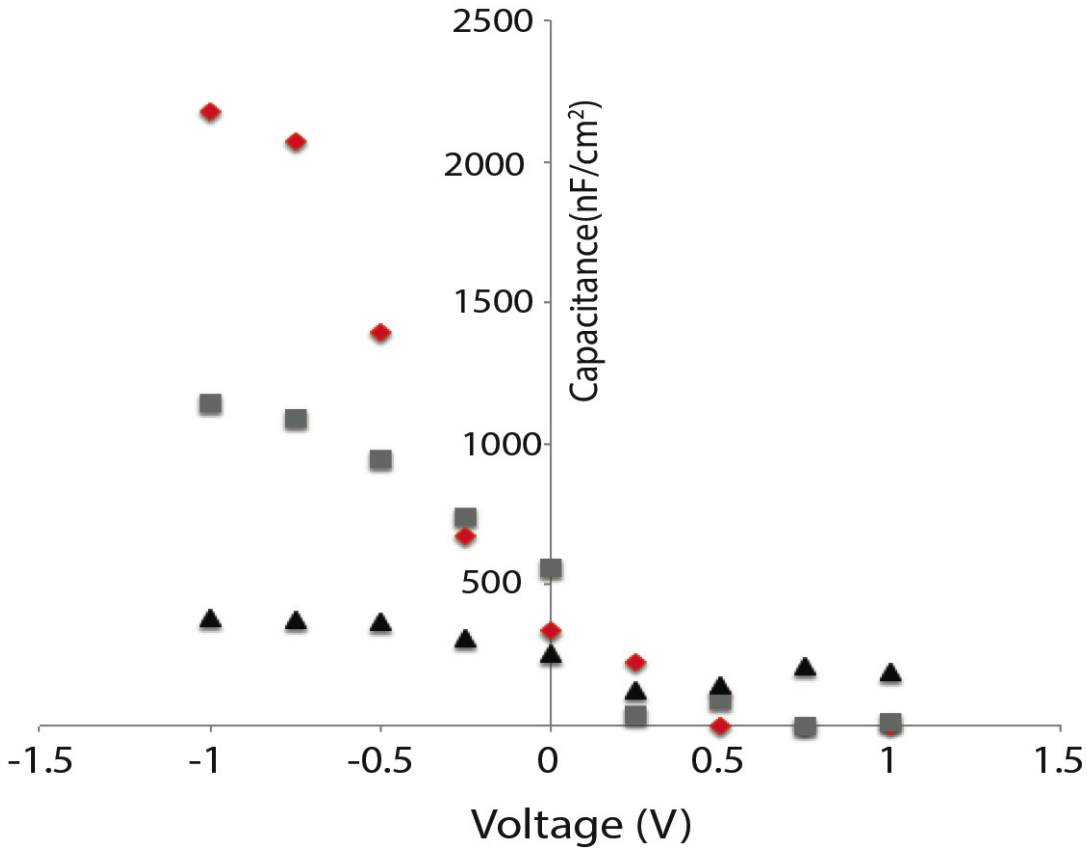

Figure S 6 High-frequency (1MHz) C-V curves for Cu_2O MIS-Schottky cells. Capacitance measurements indicate that h-BN thickness thins down up to 1-2nm by exfoliation process. (Capacitance calculation is made in accumulation state)

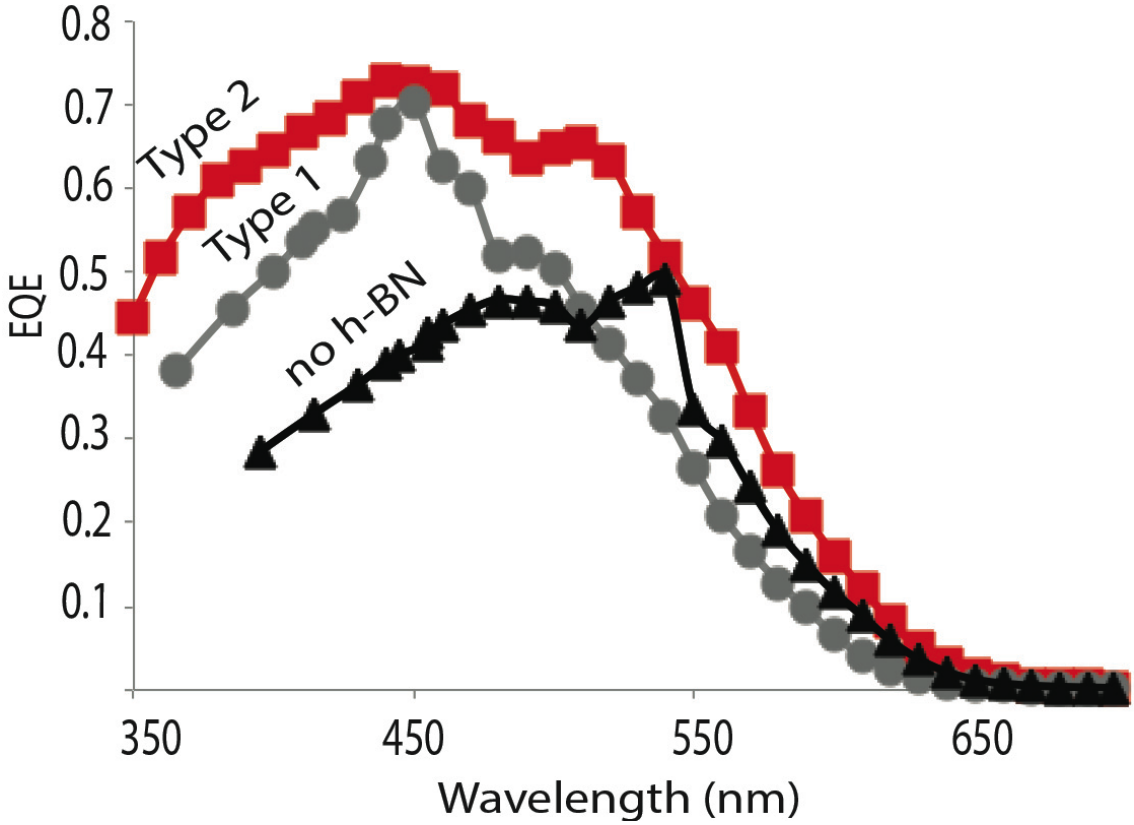

Figure S 7 External quantum efficiency (EQE) spectra of Type 1, Type 2 MIS Schottky solar cells, and Cu/Cu_2O Schottky solar cell (no h-BN) is shown. The EQE measurements show improvement of incoming photon fraction contribution in the front and rear surfaces of the Type 2 device, while only improvement on the front surface was observed in the Type 1 device. These improvements are based on using the Cu/Cu_2O Schottky solar cell (no h-BN) as the reference point.

D) AFM Study

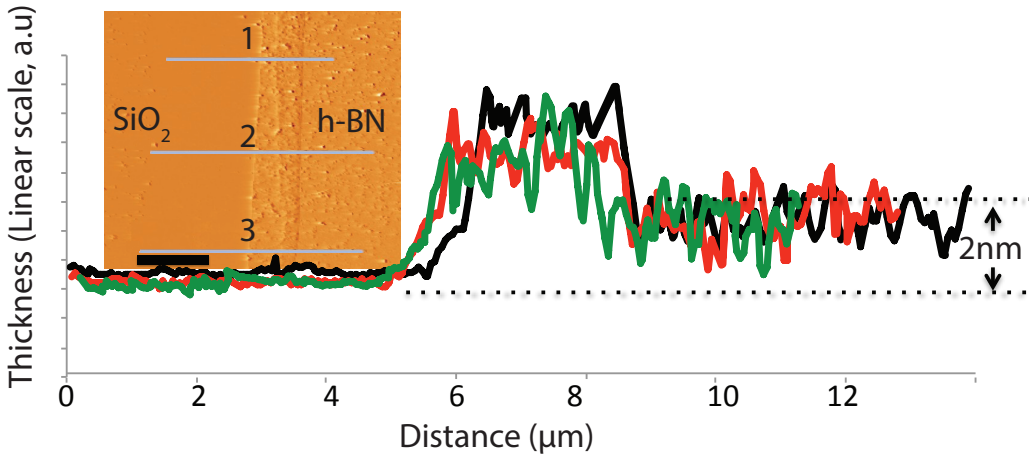

Figure S 8 AFM study of exfoliated h-BN layer which was transferred to a Si/SiO_2 substrate after Cu_2O etching. Different data sets from different line scans are shown marked as 1, 2, and 3(green, red, and black respectively), averaged over multiple lines. (Scale-bar: 4μm). h-BN folded at the edge resulting in an initial peak thickness but the AFM study confirms that h-BN thickness is around 1-2nm for the rest of the material.