***Supporting Materials***

***CuO photocathode-embedded semi-transparent photoelectrochemical cell***

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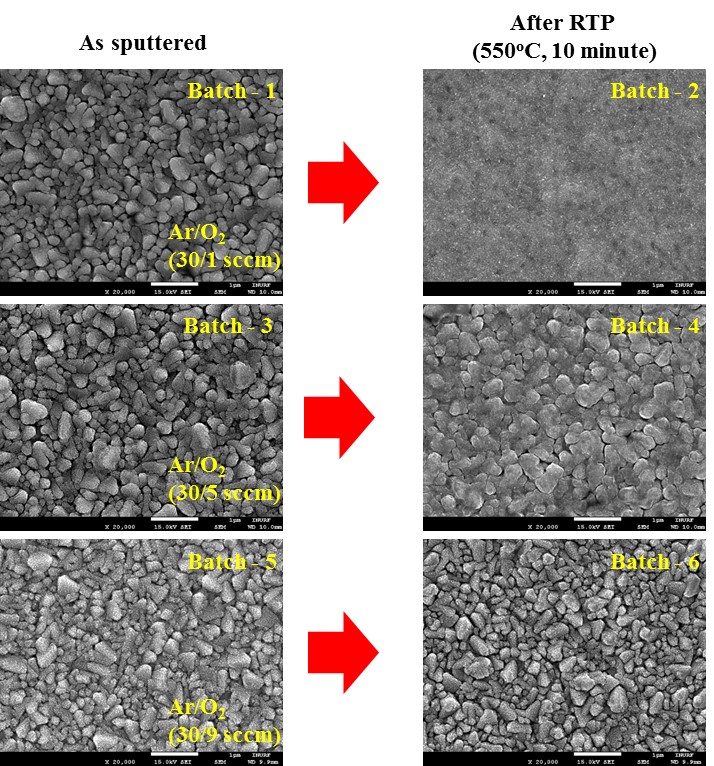
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**Table SI.** Performance comparison for our nanoscaled CuO photocathode with the CuO based photocathodes in literature. Reference potential for measured photocurrent density is mentioned as reversible hydrogen electrode (RHE), silver/silver chloride (Ag/AgCl) and saturated calomel electrode (SCE).

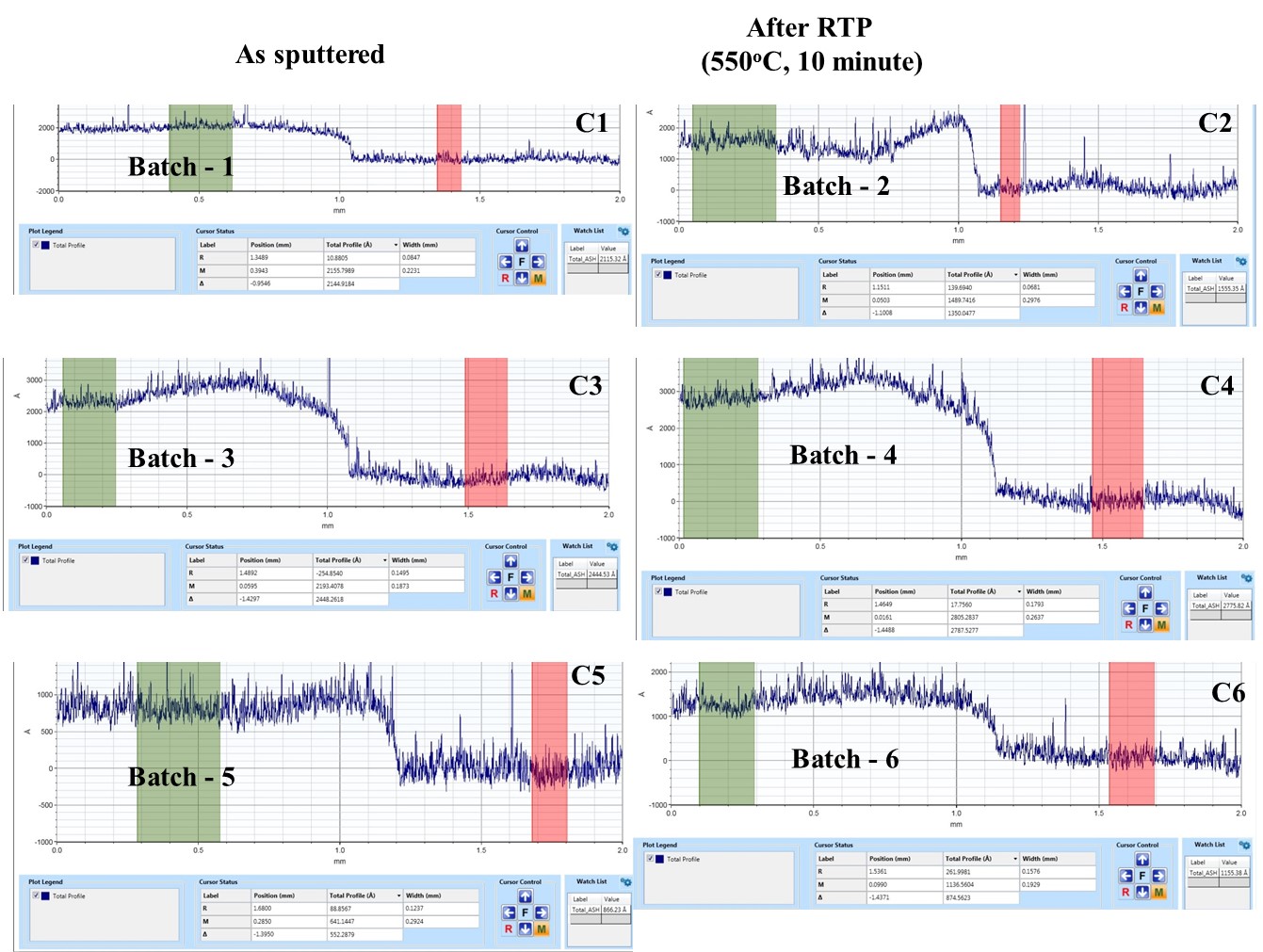
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Method of preparing CuO** | ***Eg* (eV)** | **Electrolyte** | **Light source** | **Photocurrent density**  **(mA cm-2)** | **Year/Ref.** |
| Reactive DC sputtering, room temperature | 1.85 | 0.1 M NaOH | LED, 100 mW cm-2 | 1.75 (0.3 V vs. RHE) | This work |
| Reactive DC sputtered + RTP | 1.7 | 0.1 M NaOH | LED, 100 mW cm-2 | 6.4 (0.3 V vs. RHE) | This work |
| Grind powder + LiNO3 | 1.35 | 0.1 M Na2HP04 | Xenon lamp, 810 mW cm-2 | ~0.44 (-0.4 V vs. SCE) | 1982/1 |
| Electrodeposition | 1.56 | - | 500 W xenon lamp | ~0.08 (-0.2 V vs. Ag/AgCl) | 2004/2 |
| Sol-gel | 1.77 | NaOH (pH 13) | 150 W xenon arc lamp | ~2.02 (-0.5 V vs. SCE) | 2009/3 |
| Electrochemical two stage growth | - | NaOH (pH 11) | W-halogen lamp, 125 mW cm-2 | ~0.35 (0.05 V vs. RHE) | 2010/4 |
| Spin coating of CuO particle prepared by flame spray pyrolysis | 1.44 | 1M KOH (pH 14) | 1 sun | 1.2 (-0.55 V vs. Ag/AgCl) | 2011/5 |
| RF sputtering of CuO | - | 1M KOH (pH 14) | 150 W solar simulator | ~3.15 (-0.55 V vs. Ag/AgCl) | 2012/6 |
| Flame spray pyrolysis Li:CuO | - | 1M KOH | 1 sun | ~1.69 (-0.55 V vs. Ag/AgCl) | 2012/7 |
| spinning disk reaction/spin coating | 1.68 | 1M KOH | 1 sun | 1.58 (-0.55 V vs. Ag/AgCl) | 2012/8 |
| Solution processed porous CuO | 1.35 | 1M KOH | 1 sun | 1.2 (-0.55 V vs. Ag/AgCl) | 2012/9 |
| RF co-sputtered Cu and Ti for Ti:CuO | 1.12 – 1.46 | 1M Na2SO4 | 250-W quartz tungsten lamp | 0.09 (-0.5 V vs. Ag/AgCl) | 2012/10 |
| Sol–gel | 1.2 | 0.1M Na2SO4 (pH 5.84) | 150 W Xenon arc lamp and AM1.5 filter | ~0.35 (0.05 V vs. RHE) | 2014/11 |
| Doped CuO by flame spray pyrolysis | - | 1M KOH (pH 14) | 1 sun | ~ 1.07 (-0.55 V vs. Ag/AgCl)) | 2014/12 |
| Anodising Cu foil: TiO2/CuO | - | 0.5 M K2SO4 | 300 W xenon arc lamp | 2.4 (-0.36 V vs. Ag/AgCl) | 2015/13 |
| Template assisted electrodeposition of CuO/ZnO | 1.5 | 0.1 M KOH | White light | 1.2 (-0.5 V vs. Ag/AgCl) | 2016/14 |
| RF sputtering of CuO target | 1.25 | 0.1 M Na2SO4 (pH 5.84) | 1 sun | 2.5 (0 V vs. RHE) | 2016/15 |
| RF sputtered CuO + RTP | 1.35 | 0.1 M Na2SO4 (pH 5.84) | 1 sun | 1.68 (0 V vs. RHE) | 2016/16 |
| Doped Ni:CuO by flame spray pyrolysis | - | 1M KOH (pH 14) | 1 sun | 1.07 (-0.55 V vs. Ag/AgCl) | 2016/17 |



**FIG. S1.** Photograph of samples including their classification and process conditions.



**FIG. S2.** FESEM images of the samples featuring the surface morphological variation for given synthesis condition. Left images presents as sputtered samples, the surface morphology of various Cu oxides prepared by changing the oxygen flow rate. Right images presents samples treated by atmospheric RTP, the surface morphology of nanoscaled CuO converted from various Cu oxides. Scale bar, 1 μm.



**FIG. S3.** Depth profiles of batch samples. Green marker on left side of each plot present thin film surface and red marker on right side in each plot present the substrate surface.



**FIG. S4**. Reflectance profiles of as sputtered and RTP treated samples.



**FIG. S5.** Tauc plot of RTP-treated samples.



**FIG. S6.** Current-potential characteristics in the forward bias (anodic) direction revealed the rectification nature of CuO photocathode.



**FIG. S7.** Current-time characteristics of bare CuO photocathode (Batch-2). Light intensity, 100 mW/cm2.

**Batch 6**

**Batch 4**

**Batch 2**

**FIG. S8.** Mott-Schottky plots of samples treated by RTP. These samples present various nanoscalefeatures of CuO materials. Here, 1/C2 vs. V shown for various frequencies from 500 Hz to 5 kHz. Consistence slope and intersection on potential axis firmed the accurate accepter carrier concentration and flat band potentials of these samples are attributed to the bulk properties and without involving surface states.

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