Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Inforamtion

Ambient-Processable, Printable Cu Electrodes for Flexible Device Applications: Structural Welding on a Millisecond Timescale of Surface Oxide-Free Cu Nanoparticles

Sang-Jin Oh, Yejin Jo, Eun Jung Lee, Sun Sook Lee, Young Hun Kang, Hye-Ji Jeon, Song Yun Cho, Jin-Seong Park, Yeong-Hui Seo, Beyong-Hwan Ryu, Youngmin Choi, Sunho Jeong**

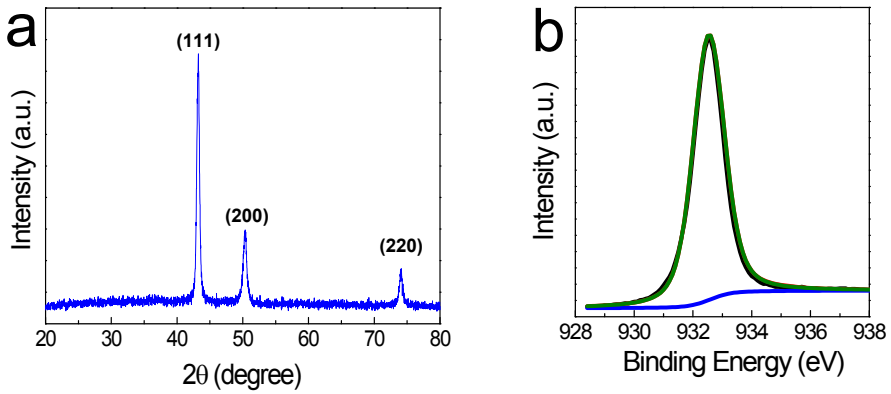


Figure S1. (a) X-ray diffraction results and (b) XPS Cu $2p_{3/2}$ spectrum for surface oxide-free Cu nanoparticles. The presence of a single symmetric peak at 932.6 eV in the XPS Cu $2p_{3/2}$ spectrum indicates the absence of any secondary phases due to oxides and impurity phases.

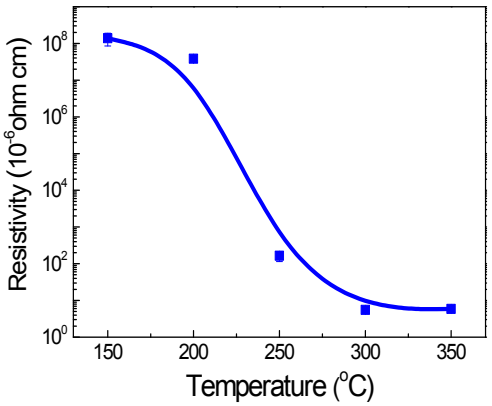
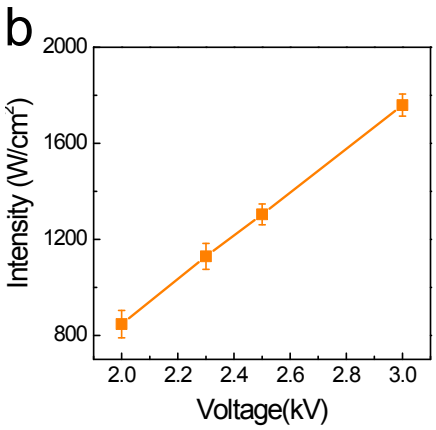


Figure S2. Resistivity evolution of Cu nano-particulate films by annealing at different temperatures up to 350 °C for 2 hr under Ar atmosphere.

a

Voltage (kV) \ Time (10^{-3} sec)	0.5	1.0	1.5	2.0
2.0	0.39	0.86	1.34	1.77
2.3	0.53	1.14	1.75	2.29
2.5	0.62	1.31	2.00	2.64
3.0	0.86	1.78	2.71	3.44

(unit: J/cm^2)



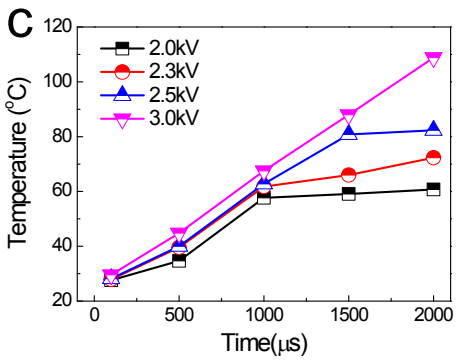


Figure S3. For a B-type lamp, (a) the variation of photon energies as a function of voltage and duration time, (b) the variation of intensity depending on the applied voltage in the range of 2.0~3.0 kV, and (c) the variation of substrate temperature as a function of voltage and duration time.

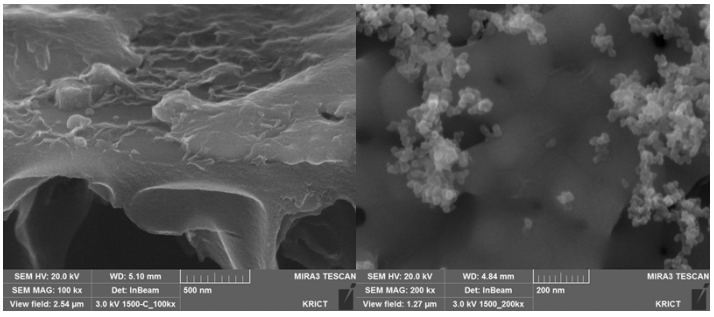


Figure S4. Cross-sectional and top-view SEM images for Cu nano-particulate films prepared on polyimide substrates after photonic sintering at 3.0 kV for 1.5 msec. The polyimide substrate was found to be significantly damaged and a part of Cu nanoparticles were present on the damaged polyimide substrate.

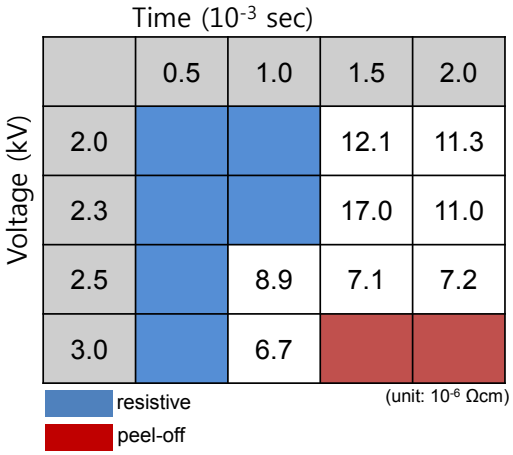


Figure S5. Resistivity evolution of Cu nano-particulate films drop-casted on polyimide substrates depending on voltage and duration time for generating photons from UV lamp.

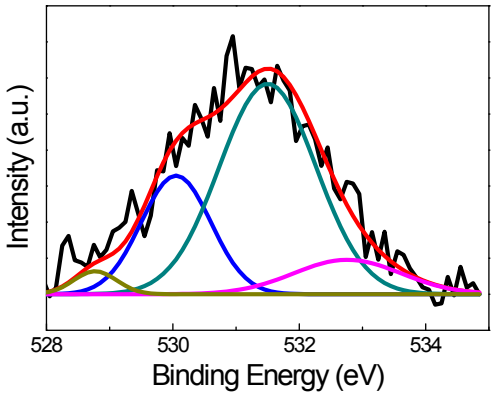


Figure S6. XPS O 1s spectrum for Cu nano-particulate films photo-sintered at 2.5 kV for 1.5 msec. The peaks positioned at 528.8, 530.1, 531.5, and 532.8 eV are attributable to Cu_2O, C=O, C-O, and unknown phase, respectively. Prior to XPS analysis, the samples were etched for 390 sec to get rid of contaminated surfaces.

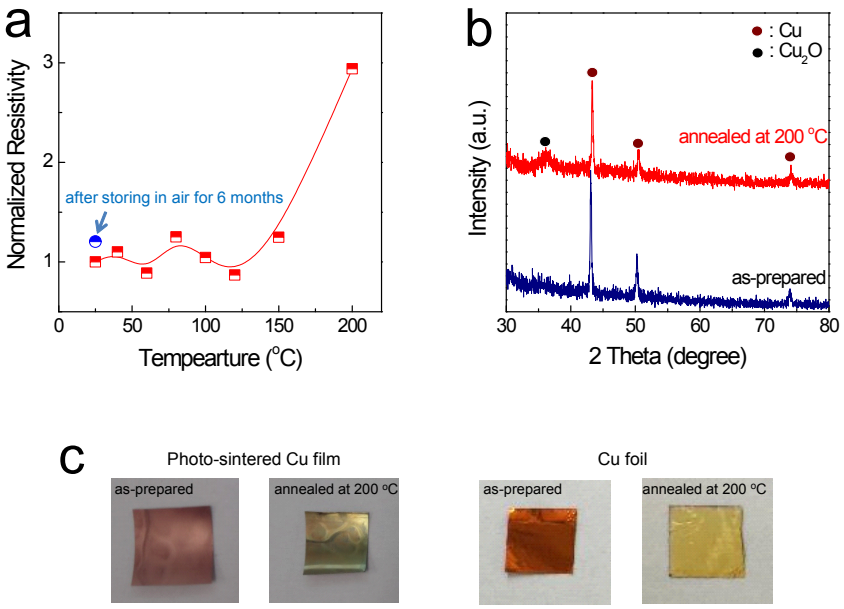


Figure S7. (a) Variation of normalized resistivity of photo-sintered Cu films as a function of annealing temperatures upto 200 °C, (b) XRD results for photo-sintered Cu films before/after annealing at 200 °C, (c) photographs for photo-sintered Cu films and Cu foils before/after annealing at 200 °C.

a

Voltage (kV) \ Time (10^{-3} sec)	0.5	1.0	1.5	2.0
2.0	0.33	0.74	1.16	1.55
2.3	0.44	0.99	1.55	2.06
2.5	0.51	1.15	1.82	2.40
3.0	0.75	1.65	2.55	3.34

(unit: J/cm²)

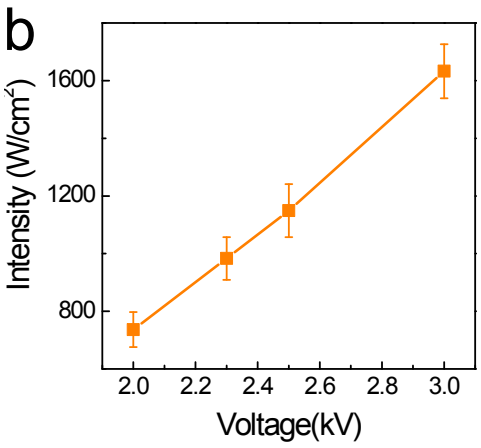


Figure S8. For an A-type lamp, (a) the variation of photon energies as a function of voltage and duration time, (b) the variation of intensity depending on the applied voltage in the range of 2.0~3.0 kV.

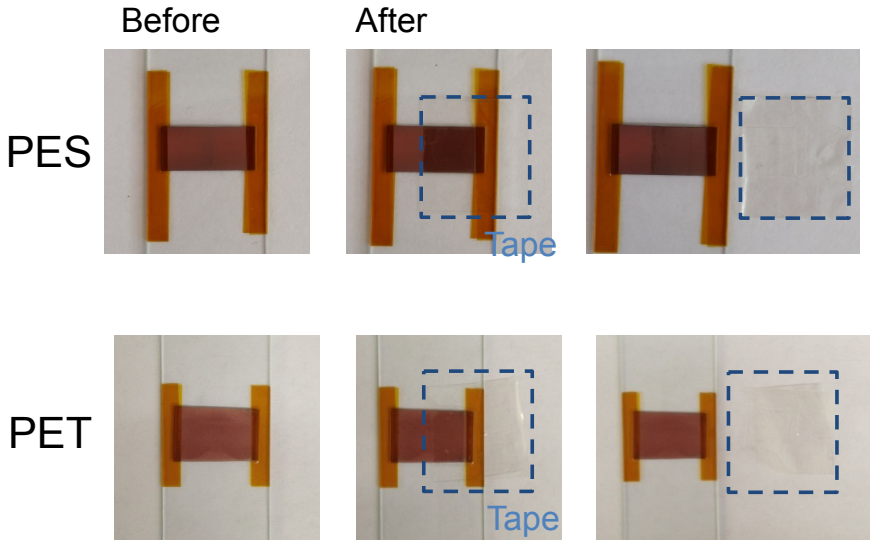


Figure S9. Adhesion tests for photo-sintered Cu layers on PES and PET substrates. The Cu layers for the PES and PET substrates were photo-sintered at 2.0 kV for 1.5 msec, and at 2.3 kV for 1.5 msec, respectively.