Electronic Supplementary Material (ESI) for Nanoscale.


**High performing AgNWs transparent conducting electrodes with 2.5Ω/Sq based upon Roll-to-Roll compatible post processing technique**

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Supporting Information

## SI-1 Further details of experimental set ups used.

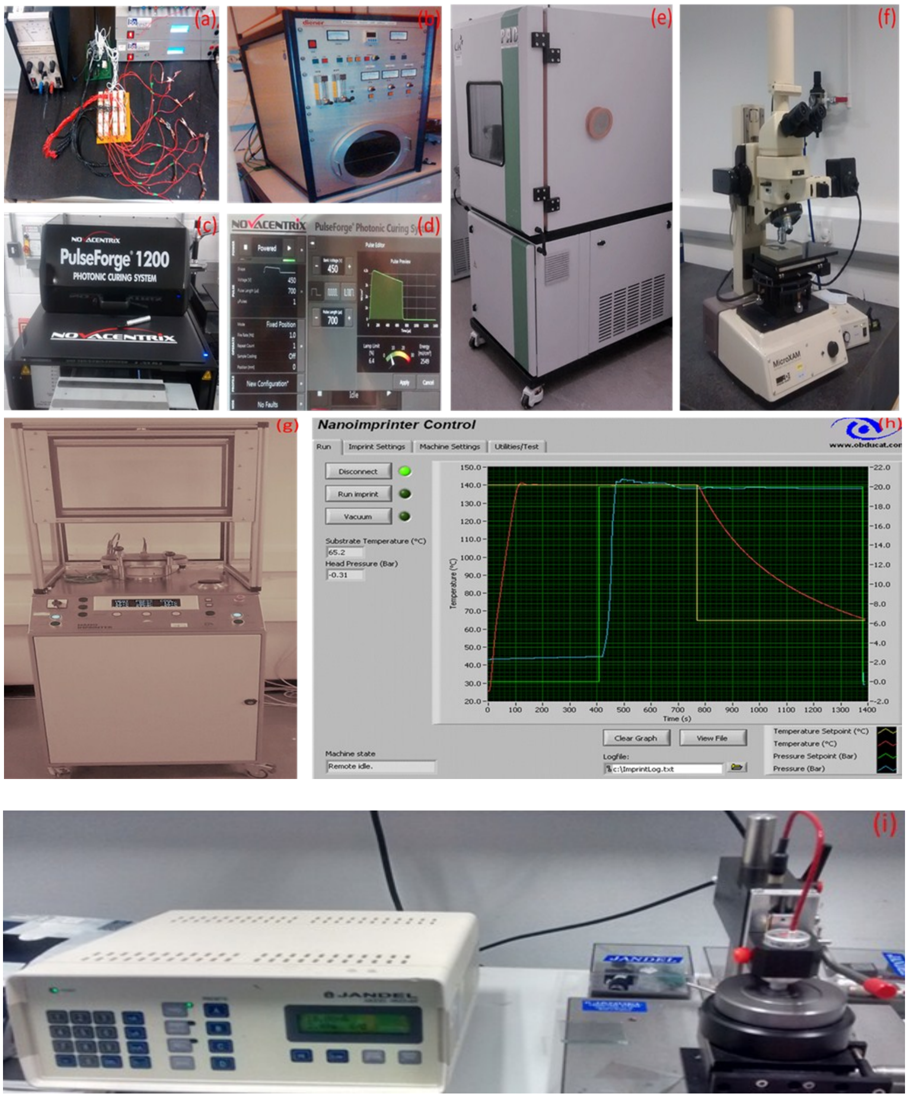



*Fig SI-1. Experimental (a) ALT setup, (b) Equipment used for N2 plasma, (c) Photonic sintering setup (d)Typical profile of photonic curing system. (e) Environmental chamber used for ALT (f). WLI equipment (g) Nano imprinter (h) Nano imprinter typical profile of controlled embossing process parameters: time, temperature and pressure (i) Measurement set up for sheet resistance display showing 2.48 Ω sq$^{-1}$ value.*

Short explanation of Setups:

(a) ALT setup: For accelerated life time testing circuit was designed and implemented on PCB using electronic devices like BJT, relays and diodes. The main parts of this set up are power supplies, Bo-test SMU for IV measurement and in house designed and built circuit board for interfacing TCEs with Bo-test. The purpose of the setup is to apply high current to TCE films which should accelerate the degradation.
(b) Equipment used for N2 plasma: The treatment process was conducted using a Diener second 'Nano' plasma treatment system at ambient pressure after a 30 seconds nitrogen purge.
(c) Photonic sintering setup: Novacentrix Pulse forge 1200 photonic curing system was used for sintering only top surface of AgNWs films.
(d) Image (d) illustrates the typical profile of photonic curing system.
(e) Environmental chamber: The climatic chamber from Alphatech was used ALT so that AgNWs samples can be placed inside this chamber for elevated temperature and humidity.
(f) WLI equipment: Surface roughness was estimated by white light interferometry (WLI) using a Micro XAM surface mapping microscope (KLA Tensor, USA).
(g) Nano imprinter: Obducat 2.5 was used compress the AgNW on the surface of PEN at different temperatures, times and pressure.

## SI-2 Absorption spectra of a post-processed AgNWs film

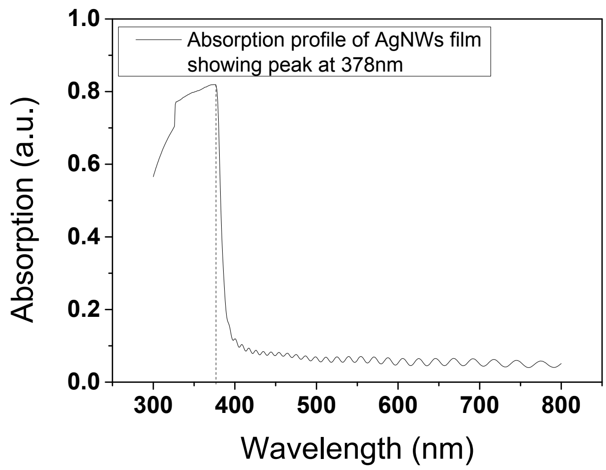



*Figure SI-2. A typical absorption profile for the AgNW film. The measurements were carried out using Lambda 35 UV/VIS Spectrometer. Transparency measurements were taken at a wavelength of 550nm.*

**SI-3 Table for standard deviation (s.d.) of sheet resistance, transmittance and haze**

| Process | $R_{sh}$ (Before Post process) $\Omega$ $sq^{-1}$ | $R_{sh}$ (After Post process) $\Omega$ $sq^{-1}$ | Percentage reduction in $R_{sh}$ (%) | Optical transmittance @ 550nm | Optical haze |
|---|---|---|---|---|---|
| Embossing | 2.11 | 1.12 | 2.07 | 1.89 | 1.23 |
| Sintering | 1.11 | 1.02 | 2.04 | 1.83 | 1.29 |
| $N_2$ plasma | 1.19 | 1.42 | 2.14 | 2.23 | 1.12 |
| Combined | 1.41 | 1.32 | 1.34 | 1.65 | 1.23 |
| Combined and with ZnO NP coating | 1.11 | 1.02 | 2.04 | 1.83 | 1.29 |
| ITO on PET | 1.31 | n/a | n/a | 1.33 | 1.4 |
| ITO on glass | 1.22 | n/a | n/a | 1.13 | 1.5 |

**SI-4 Application of AgNW films for resistive heaters. A fixed current of 100mA is applied and the temperature was measured with a thermocouple**

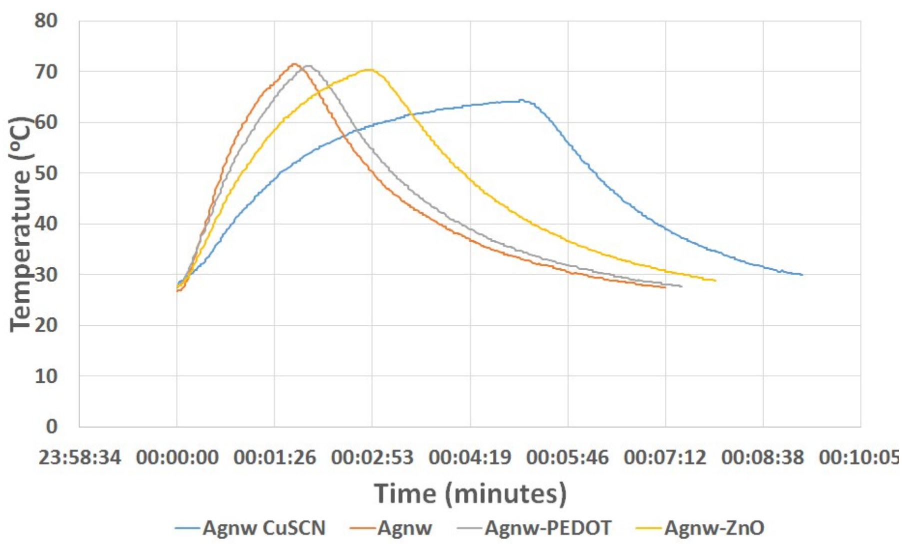
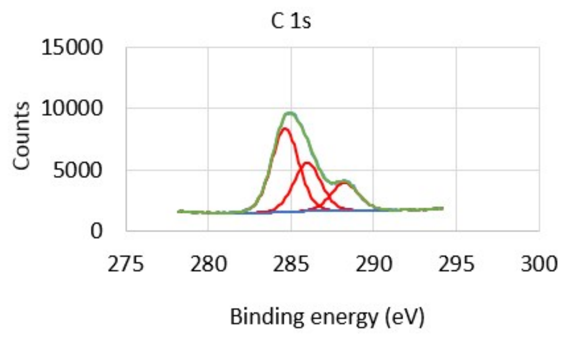
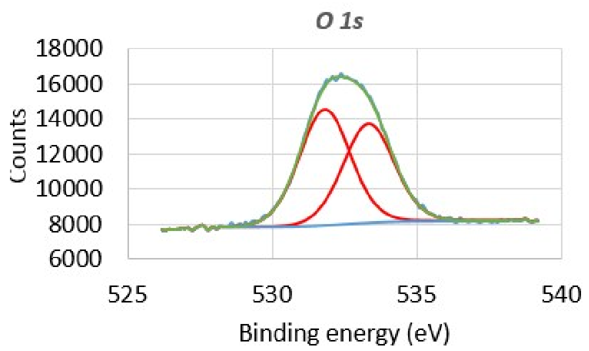


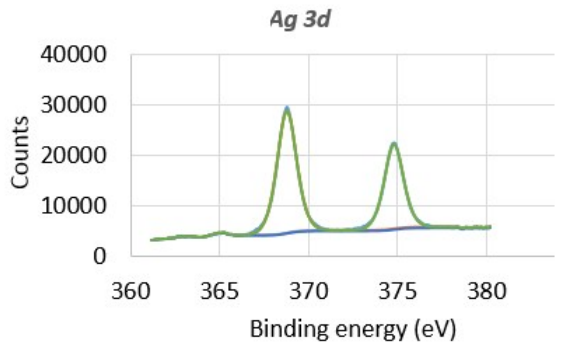

*Fig SI-4. Temperature versus time plot for various AgNWs thin films on PEN.*

**SI-5 XPS spectra of AgNWs films**

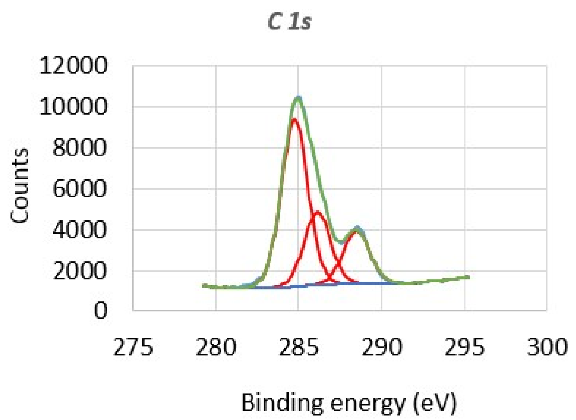
**Freshly prepared (no post processing)**

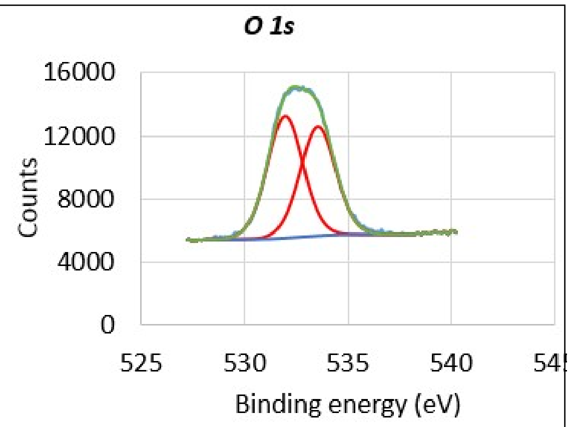


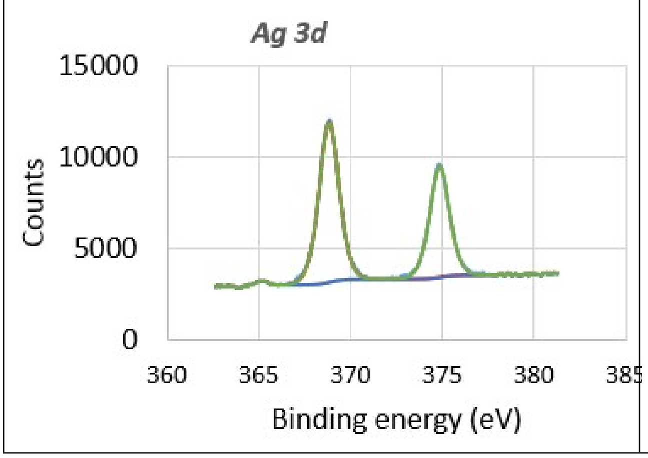




**Freshly prepared (only embossed)**



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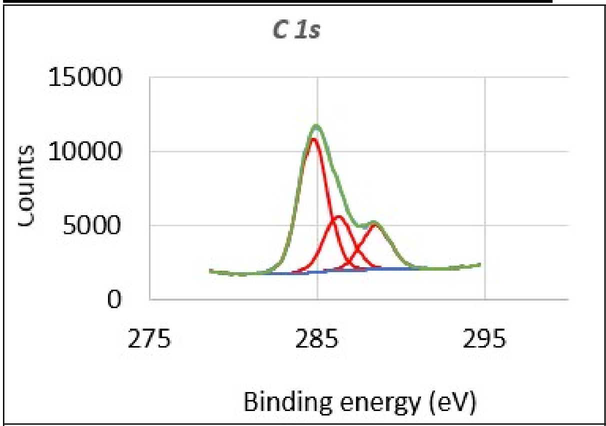
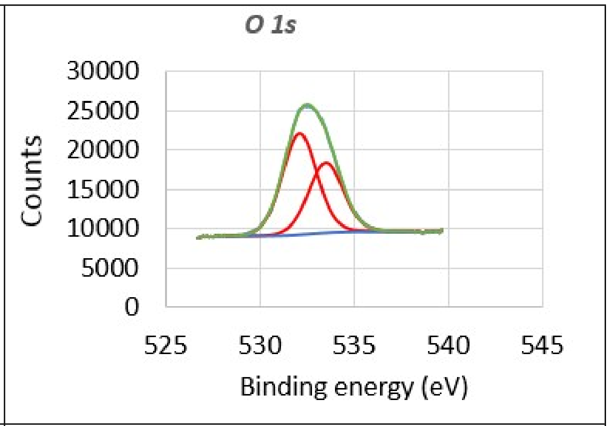
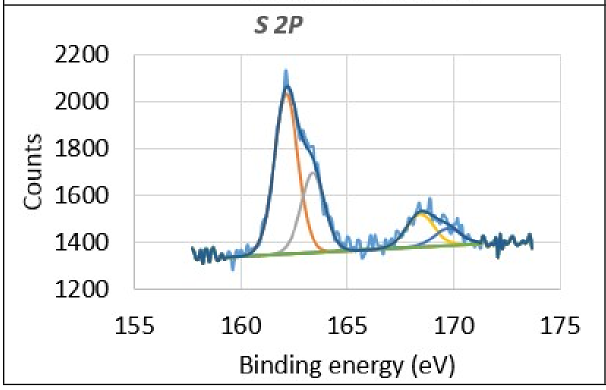
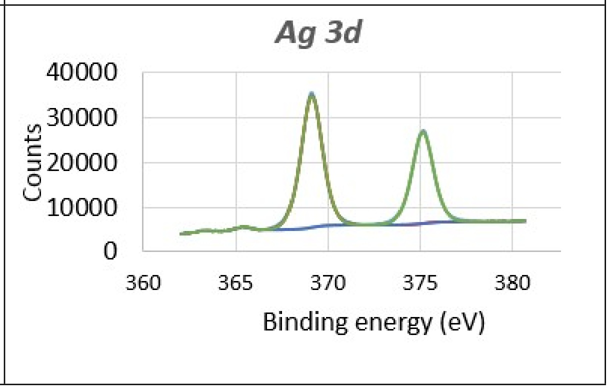
**Freshly prepared (only N2 plasma treatment)**

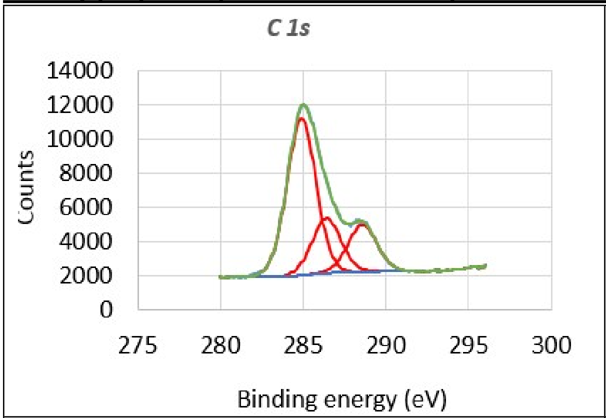


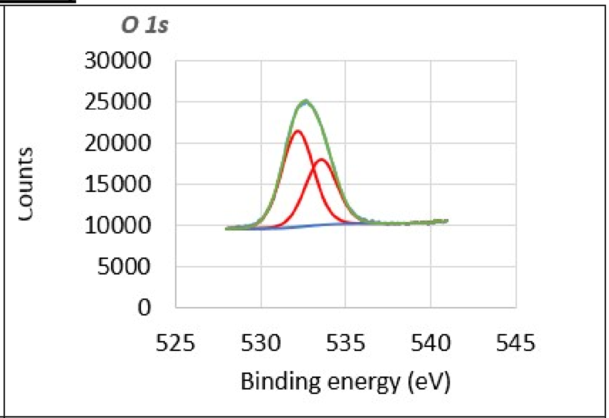



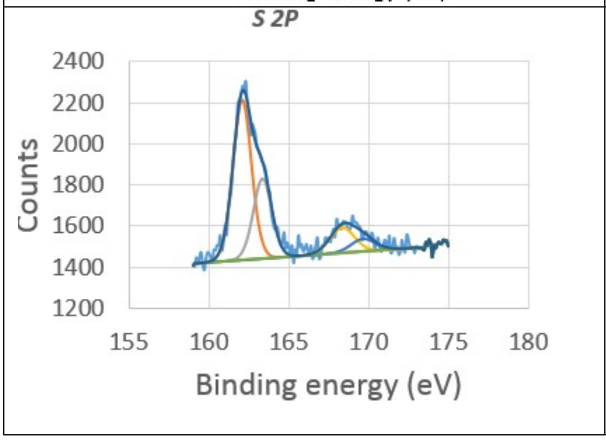



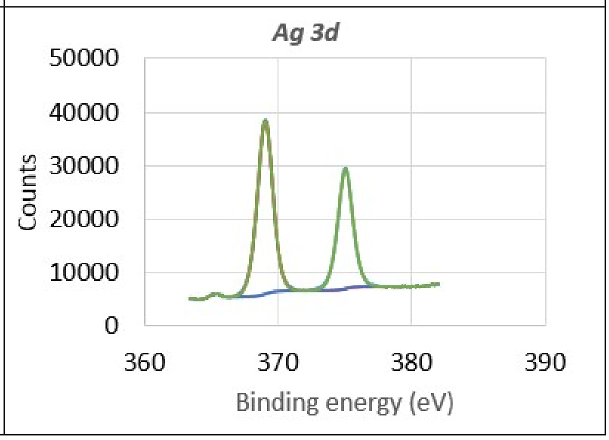




**Freshly prepared (embossed and N2 plasma treatment)**

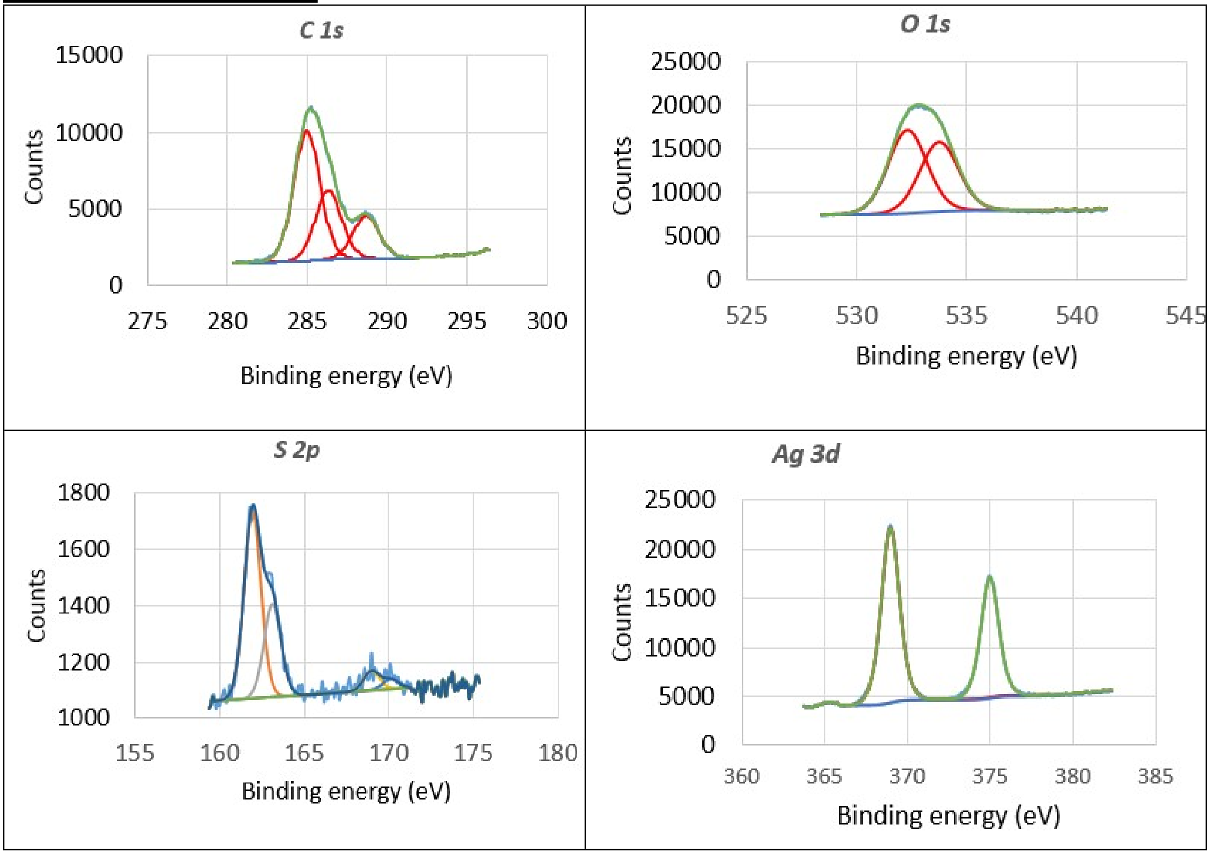


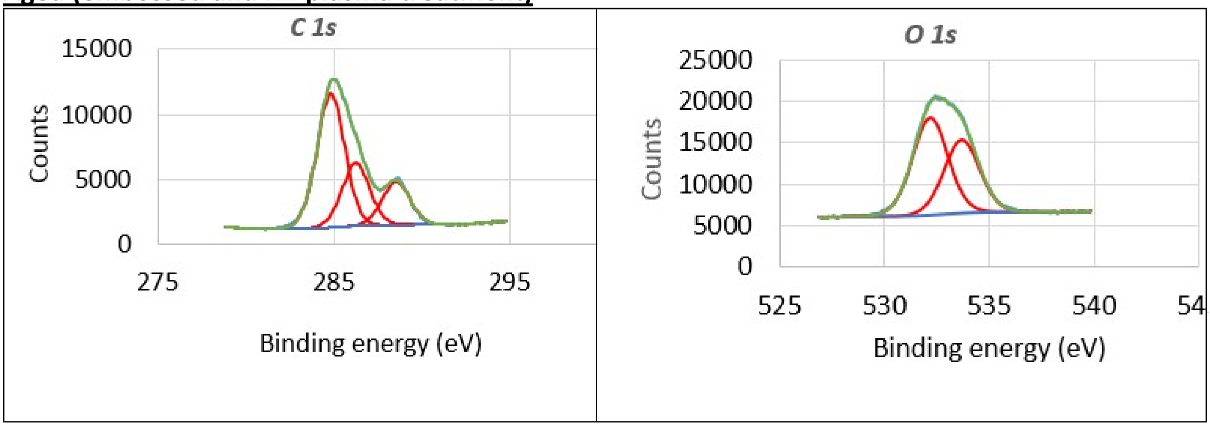



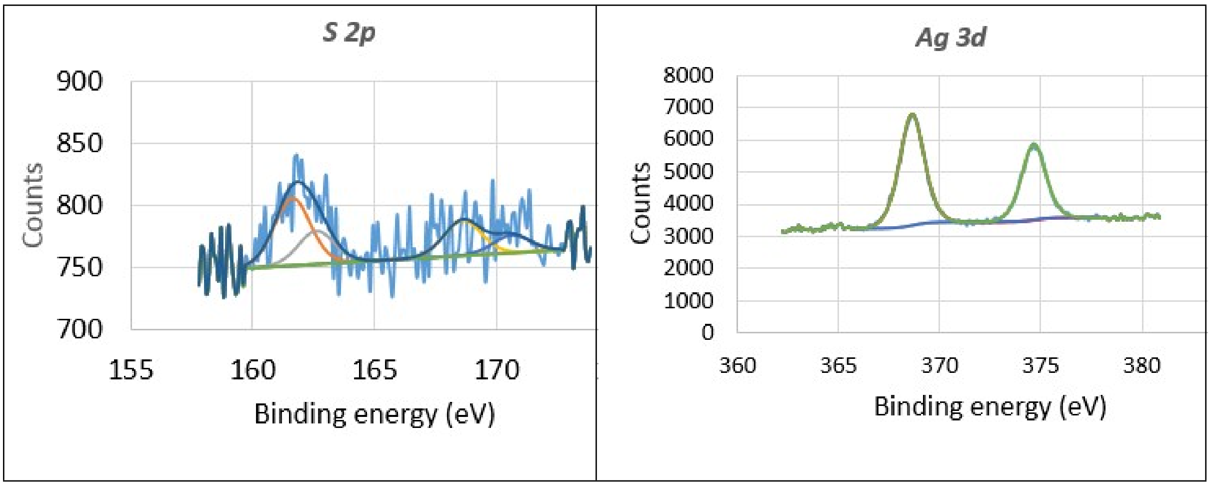



**Aged (no post processing)**




**Aged (embossed and N2 plasma treatment)**






**SI-6 A summary table of the performance of AgNWs compared with other references**

| Reference | Material | FoM | Rsh (Ω $sq^{-1}$) | T(%) |
|---|---|---|---|---|
| **[1] J. H. Park et al.** | metal grid | 45.64 | 97 | 92 |
| **[2] L. Li et al.** | metal grid | 198.33 | 9.8 | 83.1 |
| **[3] Mochizuki et al.** | | 7.39 | 301 | 85 |
| **[4] M. Y. Teo et al.** | PEDOT:PSS/EMIM | 51.88 | 80 | 91.5 |
| **[5] X. Zhang et al.** | PEDOT:PSS | 46.11 | 100 | 92.3 |
| **[6]Y. Jia et al.** | AgNWs | 207.3 | 35 | 95 |
| **[7] H. Du et al.** | AgNWs | 212.8 | 7.158 | 79.19 |
| **[8] C. Preston et al.** | AgNWs | 300 | 13 | 91 |
| **[9]L. J. Andres et al.** | AgNWs | 338 | 20.2 | 94.7 |
| **[10] A. Kim et al.** | ZnO/AgNWs/ZnO | 487.9 | 8 | 91 |
| **[11] M. Layani et al.** | AgNWs | 600.6 | 6.5 | 91 |
| **[12] S. H. Jo et al.** | CNTs/ PEDOT:PTS | 5.7 | 280 | 80 |
| **[13] M. Held et al.** | CNTs | 8.01 | 241 | 83 |
| **[14] S. Bae Jo et al.** | Graphene | 116.16 | 30 | 90 |

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|---|---|---|---|---|
| **This work** | AgNWs/ZnO NP | 932.9 | 2.48 | 85.5 |

**References for SI-6**


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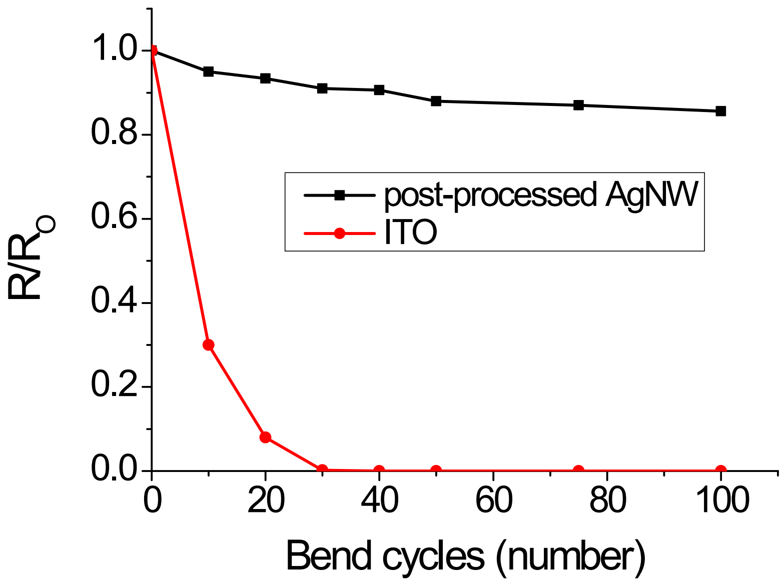
**<u>SI-7 Bend testing of AgNWs compared to performance of ITO</u>**

Shown below is the post-processed AgNW-based electrodes during repeated bending. This has been conducted with a 100-cycle test with bending radius of 20mm and compared to the incumbent technology, ITO



R/R$_O$
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Bend cycles (number)
post-processed AgNW
ITO