Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Information for:

Metal nanotrough Embedded Colorless Polyimide Film: Transparent Conducting Electrodes with Exceptional Flexibility and High Conductivity

Ji-Young Moon, Doo-Young Youn, Chanhoon Kim, Ji-Hyun Lee, Zhenhao Luo and Il-Doo Kim*

Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea

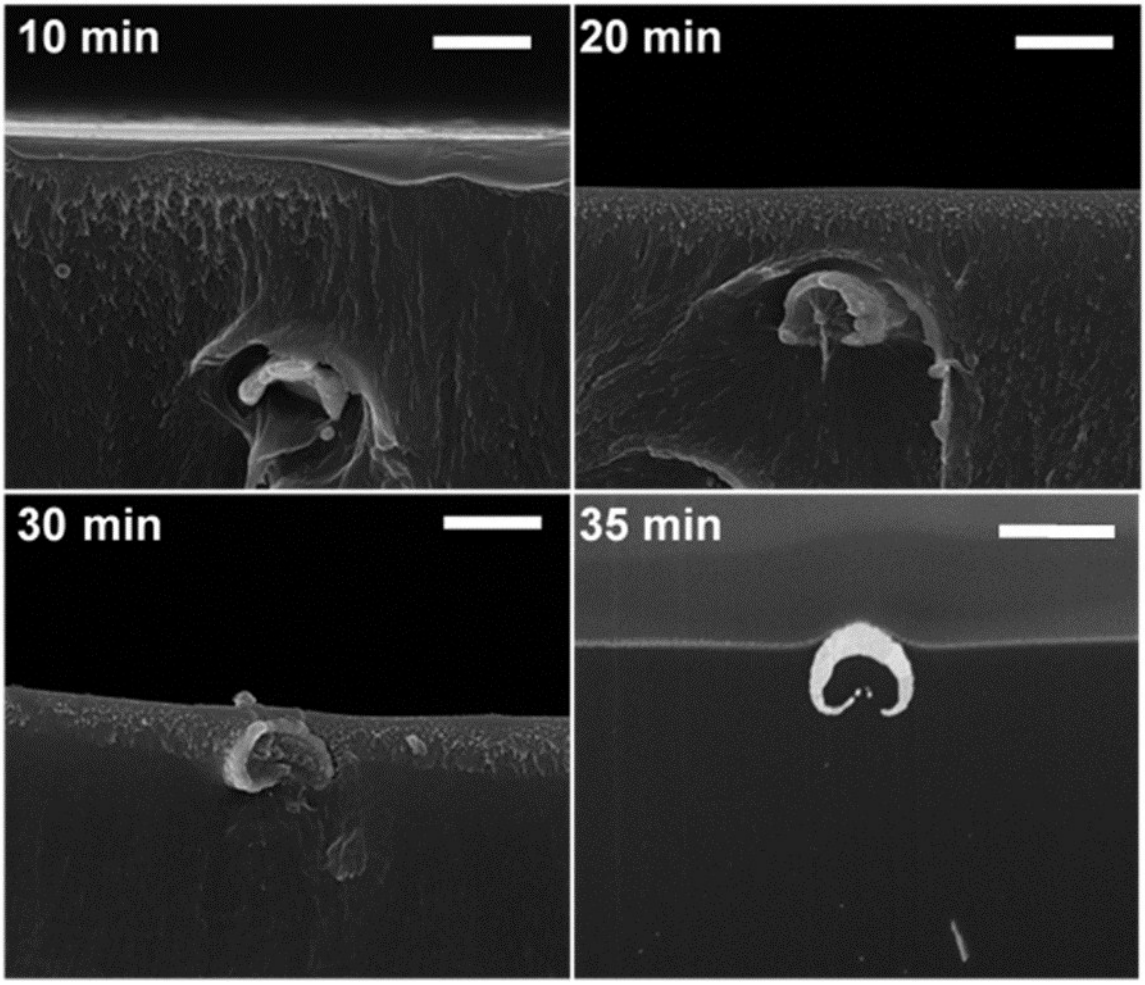

Figure S1 Cross-section SEM images of Ag NTR embedded in CPI film with varying PAA drying times. The scale bar is 1 μm

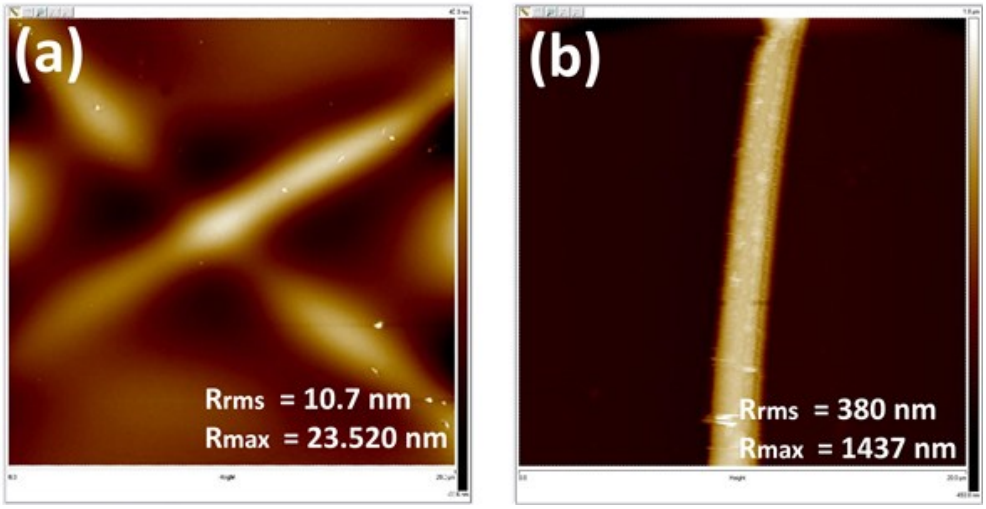

Figure S2 AFM image of (a) Ag NTR-CPI and (b) non-embedded Ag NTR on glass (The scan area is 20 μm ×20 μm)

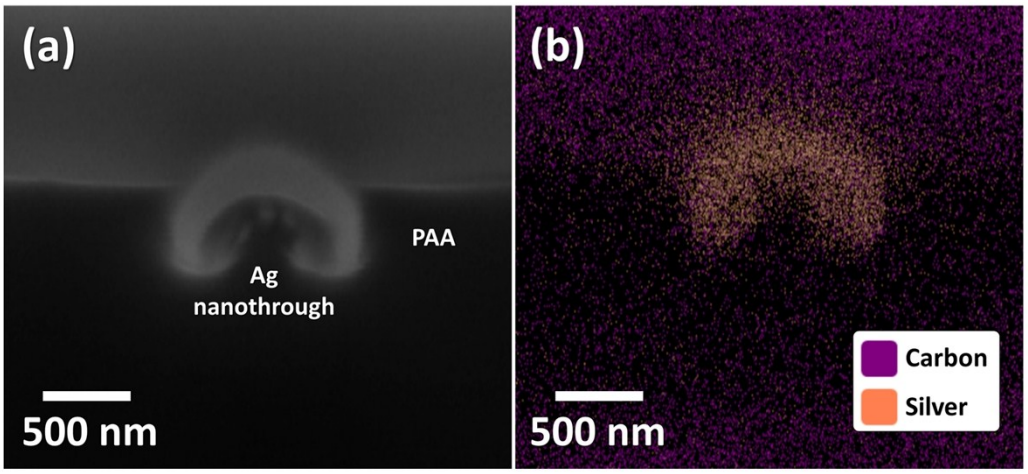

Figure S3 Cross-sectional (a) SEM image and (b) EDAX mapping image of Ag NTR embedded in PAA film as prepared in FIB

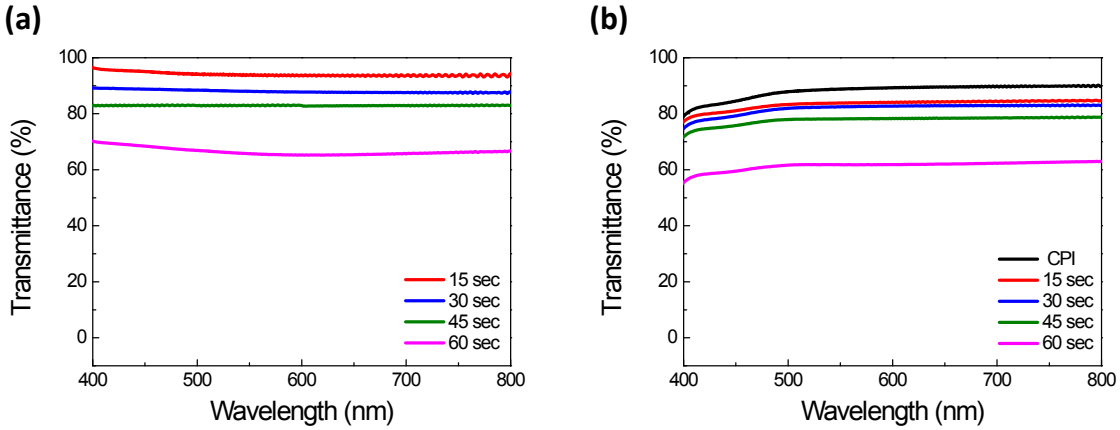

Figure S4 Optical transmittance spectra of Ag NTR-CPI film with varying electrospinning time. (a) Baseline with bare CPI film and (b) ambient air

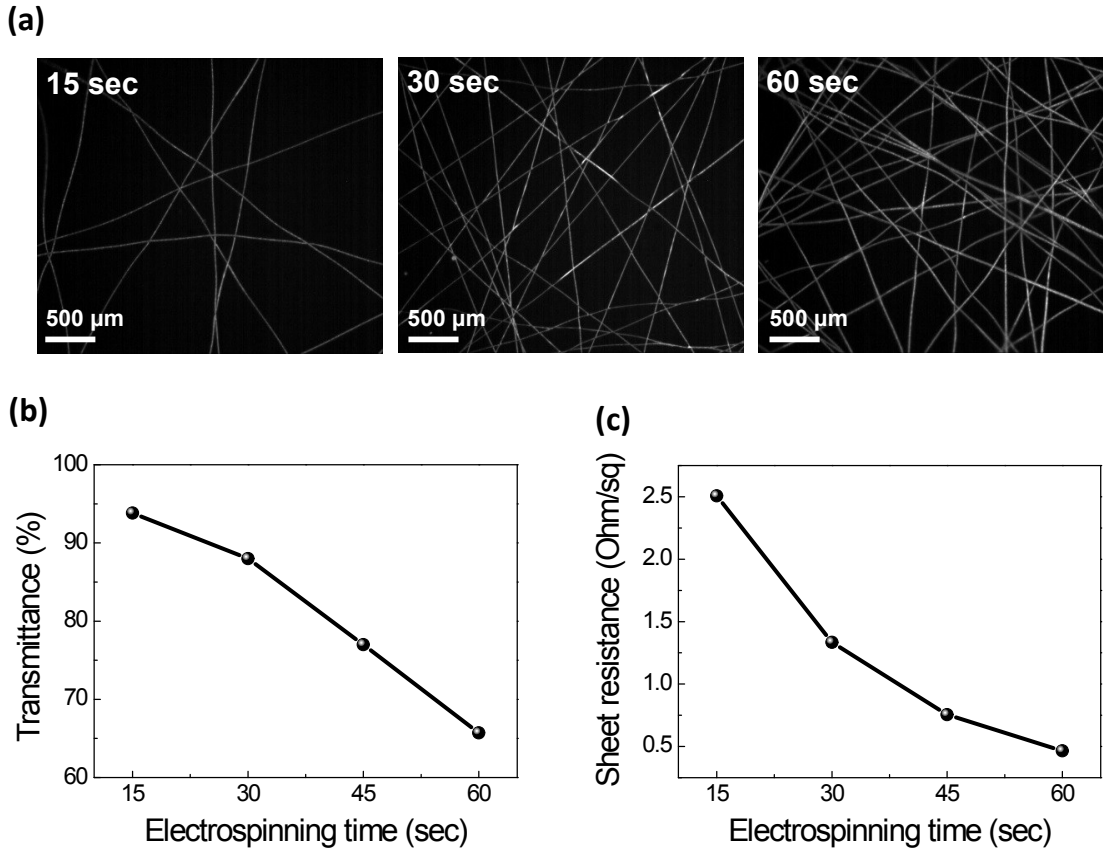

Figure S5 (a) Optical microscopy images of PAA fiber webs with varying electrospinning times. (b) Optical transmittance and (c) sheet resistance of Ag NTR-CPI as a function of electrospinning time.

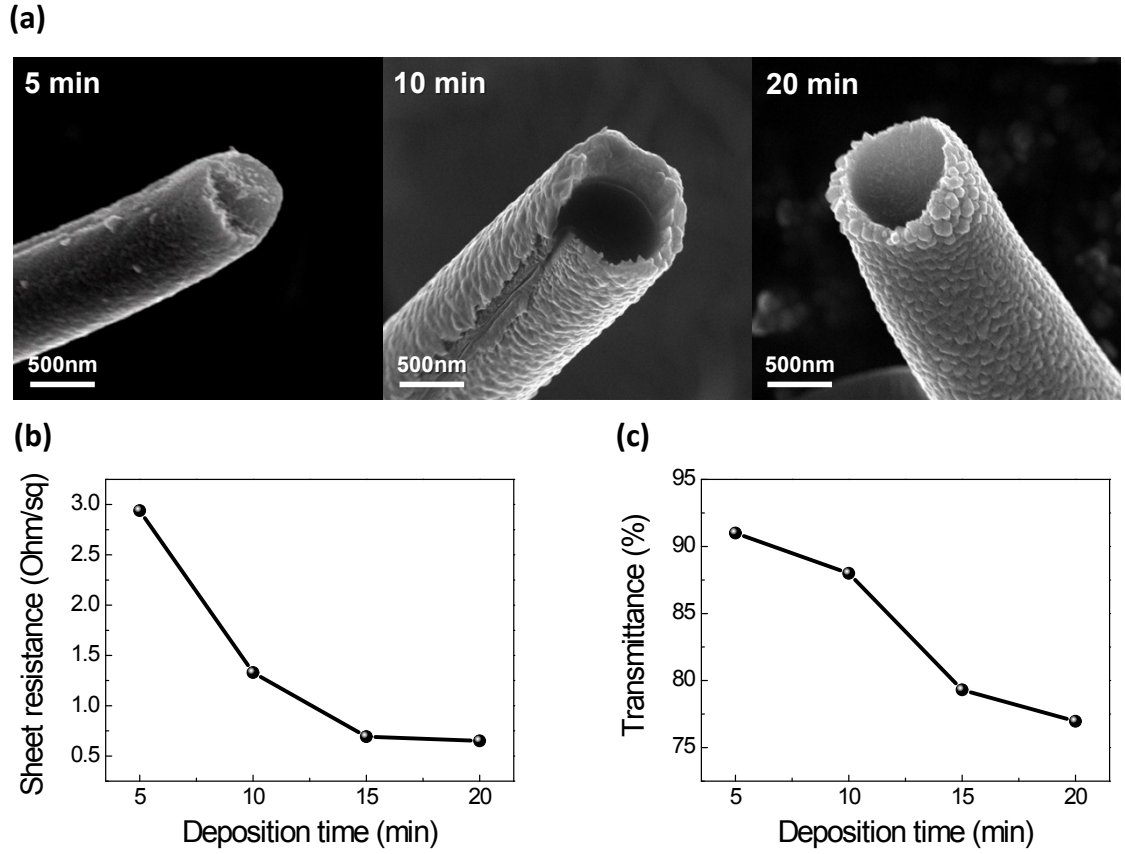

Figure S6 (a) Cross-section SEM images of Ag NTR including PAA core template with varying deposition time. (b) Sheet resistance and (c) optical transmittance of Ag deposition time of Ag NTR-CPI as a function of electrospinning time.

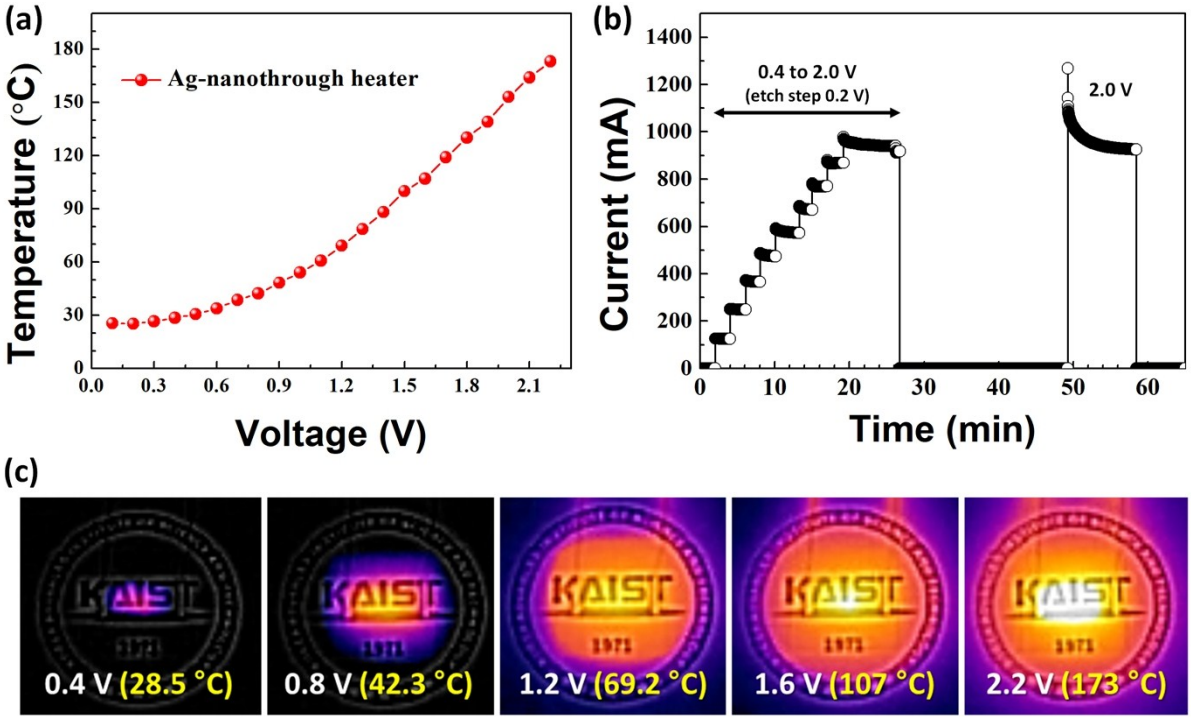

Figure S7 (a) Temperature profile of the Ag NTR-CPI by joule heating under diverse voltages. (b) Current response of the Ag NTR-CPI as a function of applied voltages ranging 0 to 2.0 V in each step for 30 sec and (b) 0 to 2.4 V in each for 5 min. (c) IR camera images of the each voltage with temperature.

Table S1. Figure of merit values corresponding to R_{sh} and T of Ag NTR-CPI and metal based TCEs, including the data in Fig. 4.

TCE	R_{sh} (Ω sq^{-1})	T_{tot} (%)	FoM ($\times 10^{-3}\Omega^{-1}$)	Ref.
Cu NW (2015)	15	86	14.753	[1]
Ag NW (2016)	9	80.4	12.541	[2]
Ag mesh (2016)	4	85	49.219	[3]
Ag grid (2016)	8.5	85.5	24.561	[4]
Ag NF (2016)	1.12	69.24	22.613	[5]
Cu grid (2016)	12.9	87.1	19.48	[6]
PEDOT:PSS/Ag NW (2017)	25.4	89	12.28	[7]
Dual-scale Ag NW (2017)	50	90	6.97	[8]
Au NTR in GFRhybrimer (2016)	2	90	174.43	[9]
This work (Ag NTR-CPI)	1.33	88.0	209.16	-

References

1. F. Cui, Y. Yu, L. Dou, J. Sun, Q. Yang, C. Schildknecht, K. Schierle-Arndt and P. Yang, *Nano lett.*, 2015, **15**, 7610-7615.
2. Y. Chen, W. Lan, J. Wang, R. Zhu, Z. Yang, D. Ding, G. Tang, K. Wang, Q. Su and E. Xie, *Phys. E*, 2016, **76**, 88-94.
3. Y. Liu, S. Shen, J. Hu and L. Chen, *Opt. Express*, 2016, **24**, 25774-25784.
4. S. M. Yang, Y. S. Lee, Y. Jang, D. Byun and S.-H. Choa, *Microelectron. Reliab.*, 2016, **65**, 151-159.
5. R. Song, X. Li, F. Gu, L. Fei, Q. Ma and Y. Chai, *RSC Adv.*, 2016, **6**, 91641-91648.
6. B.-J. Kim, J.-S. Park, Y.-J. Hwang and J.-S. Park, *Appl. Surf. Sci.*, 2016, **380**, 2-7.
7. S. Sung and T. W. Kim, *Appl. Surf. Sci.*, 2017, **411**, 67-72.
8. J. Lee, K. An, P. Won, Y. Ka, H. Hwang, H. Moon, Y. Kwon, S. Hong, C. Kim, C. Lee and S. H. Ko, *Nanoscale*, 2017, **9**, 1978-1985.
9. H. G. Im, B. W. An, J. Jin, J. Jang, Y. G. Park, J. U. Park and B. S. Bae, *Nanoscale*, 2016, **8**, 3916-3922.