Electronic Supplementary Material (ESI) for RSC Advances.

Roll-to-Roll Processed, Highly Conductive, and Flexible Aluminum (Al) Electrodes based on Al Precursor Inks

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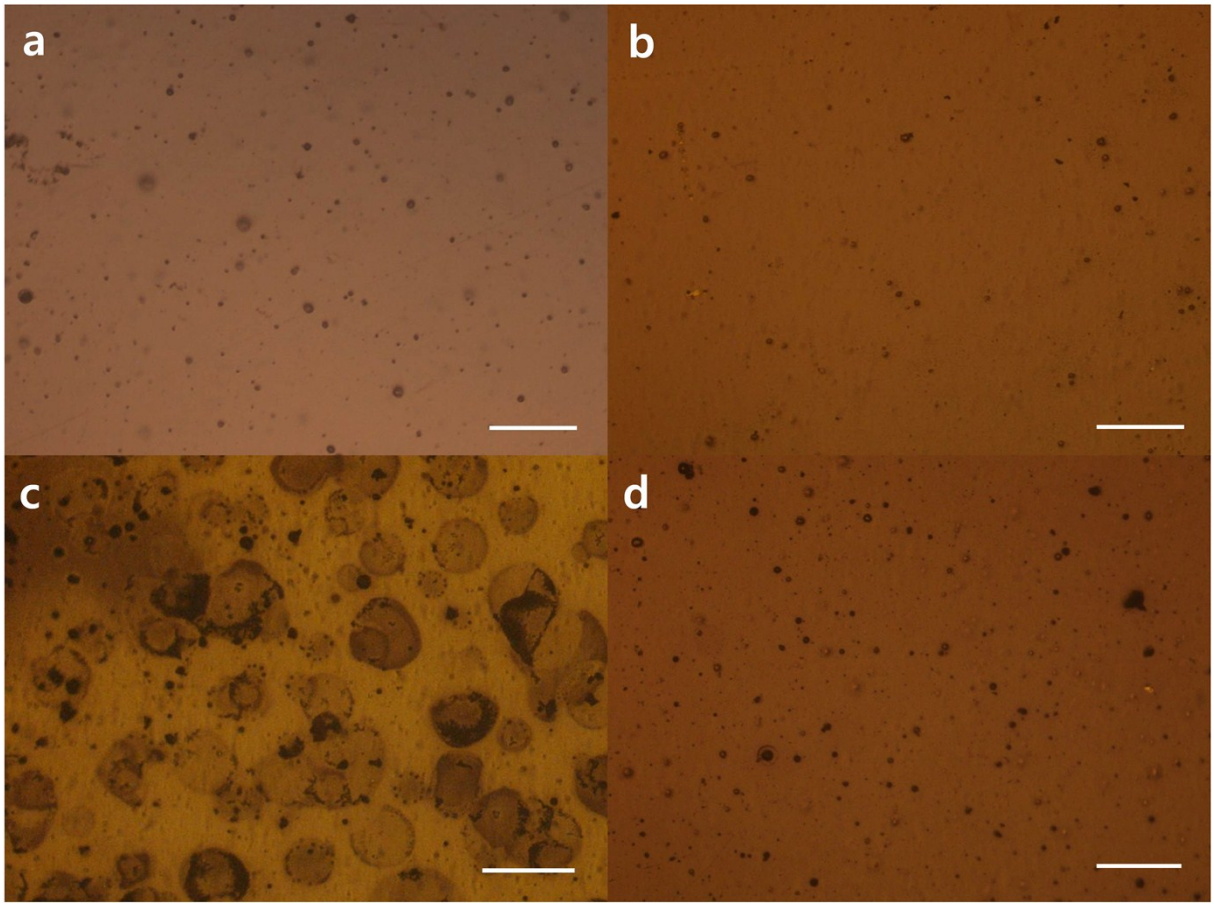

Fig. S1. Optical micrographs of the PI films. The images were captured before and after coating the films with a 100:1 diluted catalyst. The size of the scale bar is 100 μm. (a) Bare PI film before coating with the diluted catalyst, (b) PI film coated with the diluted catalyst by the slit-die coating method, (c) PI film coated with the diluted catalyst by the spray coating method, and (d) PI film coated with the diluted catalyst by the micro-gravure coating method

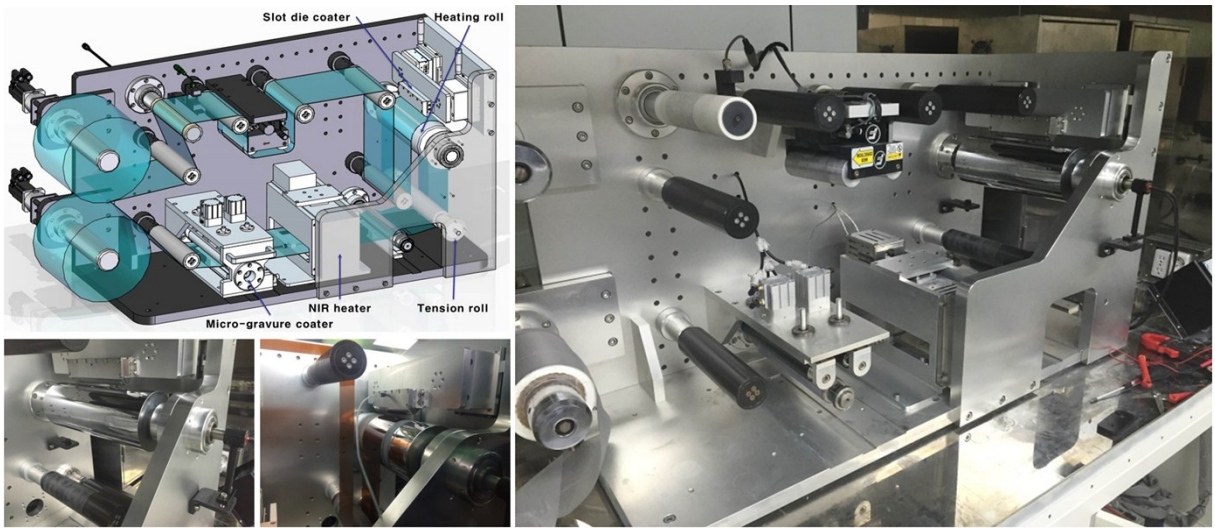

Fig. S2. Scheme and images of the R2R coating system. The images were captured before the glove box was sealed. (a) Scheme of the R2R coating system showing the positions of the coater and heater, (b) heating roll before inserting the PI film, (c) heating roll after inserting the PI film, and (d) R2R coating system placed inside the glove box

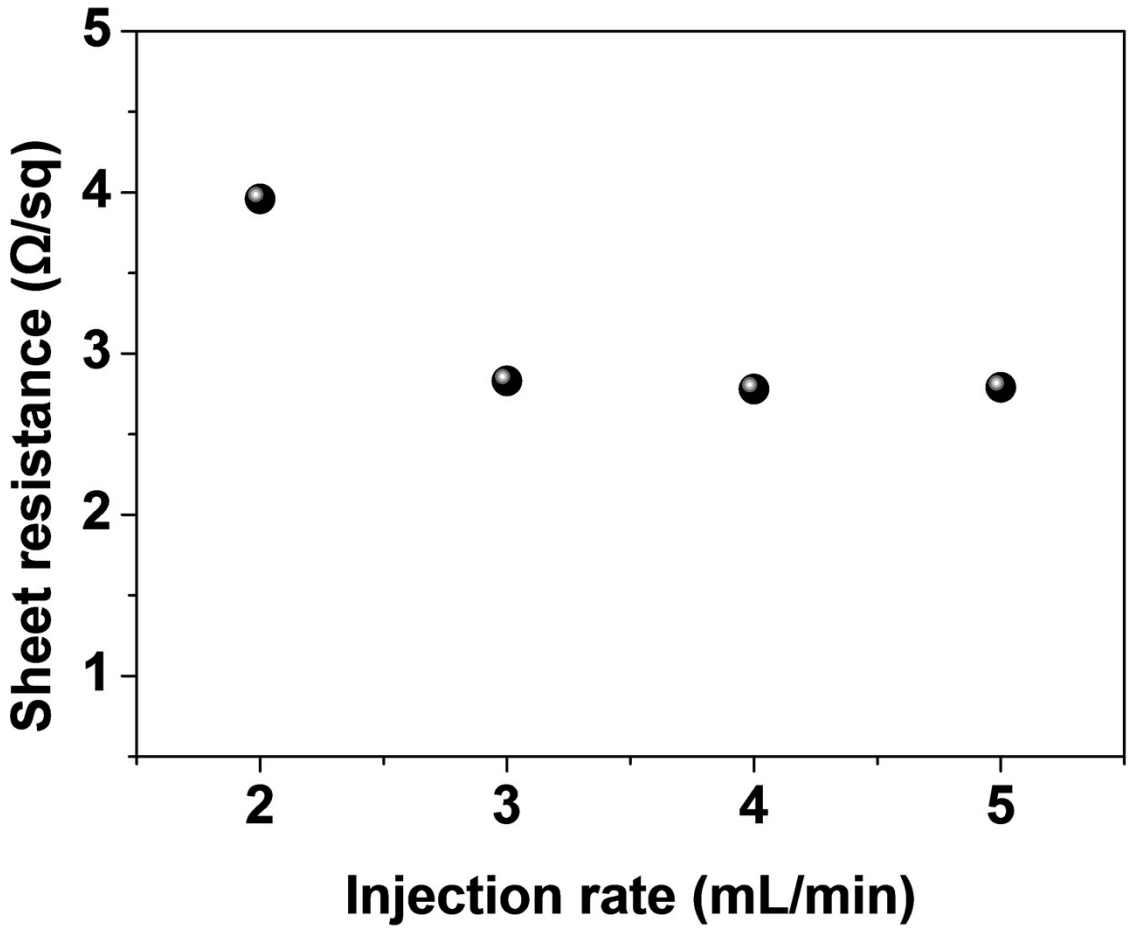

Fig. S3. Sheet resistance of the Al film coated on the PI film as a function of the injection rate. This graph proves that adjusting the injection rate does not affect the thickness of the Al ink layer.

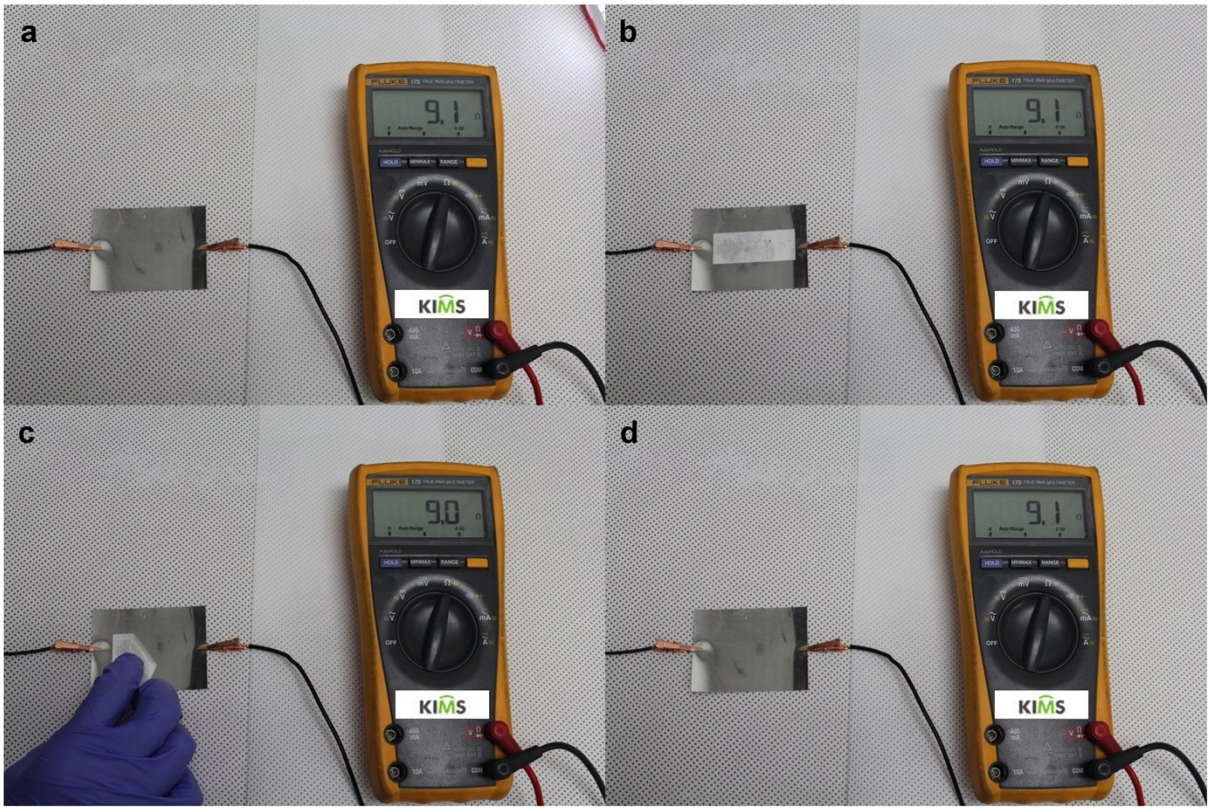

Fig. S4. Taping test results of the Al film coated on a PI film. (a) to (d) prove the high adhesion of the Al film with the target film; it can be seen that there was no change in the resistance after directly attaching and removing 3M Scotch tape from the film.

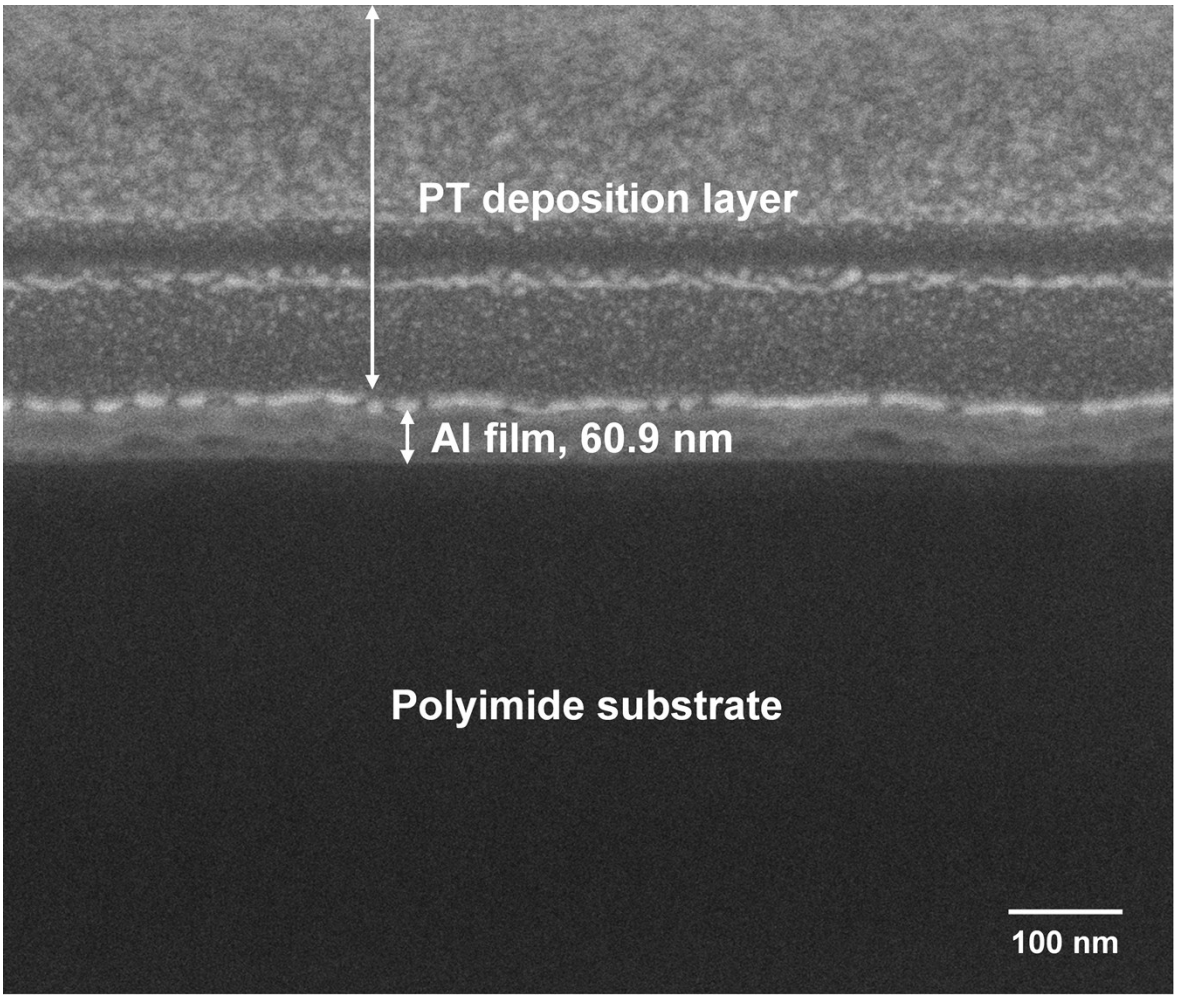

Fig. S5. SEM images of the cross section of the Al film cutted with focused ion beam. Thickness of the Al film is 60.9 nm.

Resistivity of the Al film can be calculated by the equation below.

$$\rho = R_s t$$

Here, ρ, R_s and t represent resistivity, sheet resistance and thickness of the Al film respectively. Since the average of the sheet resistance was 2.8 Ω sq^{-1} and the thickness of the Al film is 60.9 nm, resistivity of the Al film is 170.5 nΩ · m. The resistivity of the bulk Aluminum is 26.5 nΩ · m. Normally, Al oxide does not affect the resistivity in the case of the bulk aluminium, but Al film coated in the PI film is thin enough that the Al oxide layer could affect the resistivity. Also, resistivity of the silver films prepared by solution using nanoparticles with annealing process at 150 °C shows higher resistivity compared to bulk silver. The resistivity of the silver film printed by normal solution process is larger than 5 ~ 10 times than that of bulk silver.[R1, R2]

R1) Highly conductive short chain carboxylic acid encapsulated silver nanoparticle based inks for direct write technology applications. Journal of Materials Chemistry C 2013, 1 (3), 572-579

R2) Inkjet printed fractal-connected electrodes with silver nanoparticle ink. ACS applied materials & interfaces 2012, 4 (6), 3300-3307