Electronic Supplementary Information

Conductive Silver Coating with Ultra-low Silver Consumption on Polyimide Film via a Mild Surface Ion Exchange Self-metallization Method

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Table S1 The Ag consumption and sheet resistance of silver layer on polyimide film fabricated by different methods

Methods	Ag(wt%)	***R***□(Ω/sq)
Inverse CVD[1]	10	NC
Single-stage self-metallization[2]	8	NC
Surface ion exchange self-metallization[3]	1.22	NC
OIR	0.56	261±1.3

Note: NC: non-conductive

The calculation process of the Ag consumption of the silver layer by surface ion exchange self-metallization[3] and OIR method

I Surface ion exchange self-metallization method[3]

As reported in reference 3, we choose ***R***□ value when the Ag loading content C_I is 0.4μmol/cm^2. The molar mass of Ag M is 107.87g/mol. The thickness of polyimide film d_I is 50μm, the area of polyimide film S_I is set as 1cm^2 and the density of polyimide film ρ is set as 1.4g/cm^3.The silver layer was fabricated on upside and downside of polyimide film at the same time. So the Ag consumption of the silver layer ω_I by surface ion exchange self-metallization method[3] can be calculated as follows:

$$\omega_I = \frac{2C_I S_I M}{2C_I S_I M + \rho S_I d_I} \times 100wt\%$$

$$\omega_I = \frac{2 \times 0.4 \times 10^{-6} \times 1 \times 107.87}{2 \times 0.4 \times 10^{-6} \times 1 \times 107.87 + 1.4 \times 1 \times 50 \times 10^{-4}} \times 100wt\% = 1.22wt\%$$

II OIR method

The Ag loading content C_{II} is 0.914μmol/cm^2. The molar mass of Ag M is 107.87g/mol. The thickness of polyimide film d_{II} is 125μm, the area of polyimide film S_{II} is set as 1cm^2 and the density of polyimide film ρ is set as 1.4g/cm^3. The silver layer was fabricated on the bright side of polyimide film. So the Ag consumption of the silver layer ω_{II} by OIR method can be calculated as follows:

$$\omega_{II} = \frac{2C_{II}S_{II}M}{2C_{II}S_{II}M + \rho S_{II}d_{II}} \times 100wt\%$$

$$\omega_{II} = \frac{0.914 \times 10^{-6} \times 1 \times 107.87}{0.914 \times 10^{-6} \times 1 \times 107.87 + 1.4 \times 1 \times 125 \times 10^{-4}} \times 100wt\% = 0.56wt\%$$

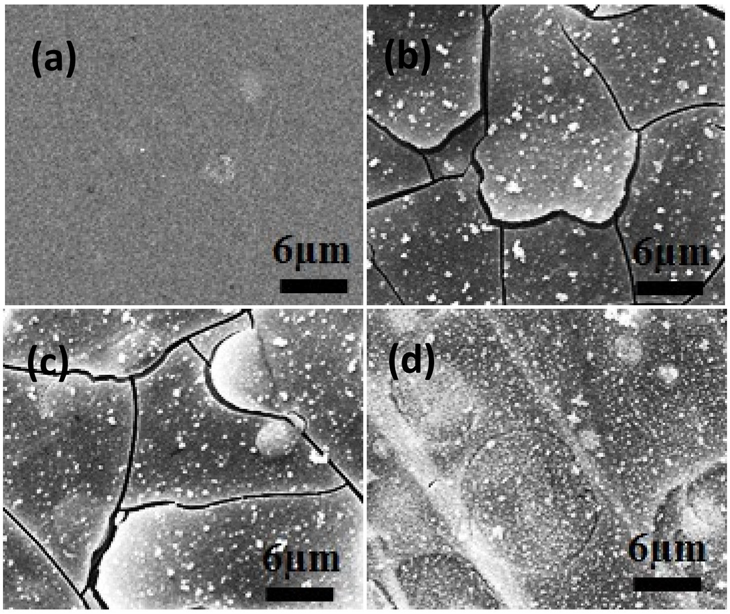

Figure S1 SEM images of progress of fabricating conductive silver coating by OIR method on polyimide film (a) after chemical degreasing process (b) after O process (c) after I process (d) after R process.

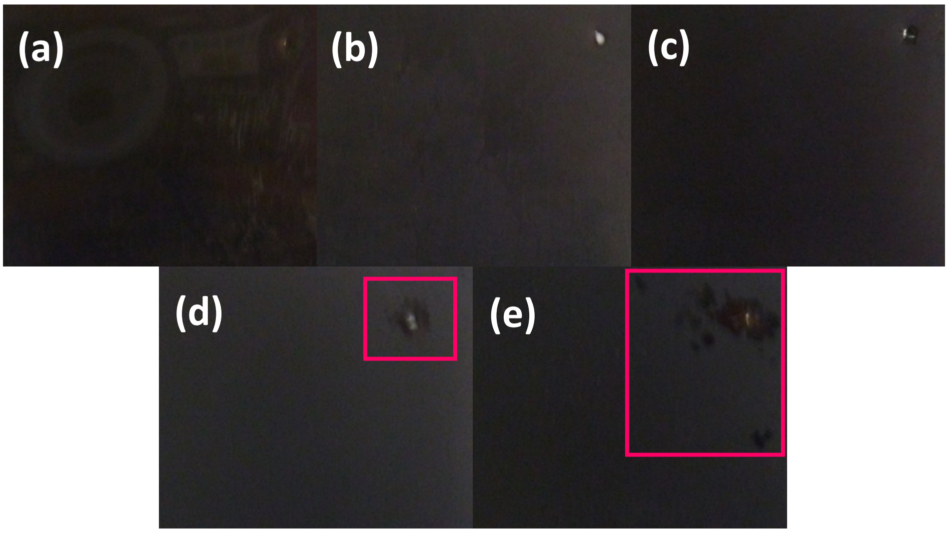

Figure S2 Digital photographs of manganese oxide modified layer under different $\boldsymbol{t_O}$ (a) 1 h (b) 3 h (c) 5 h (d) 7 h (e) 9 h

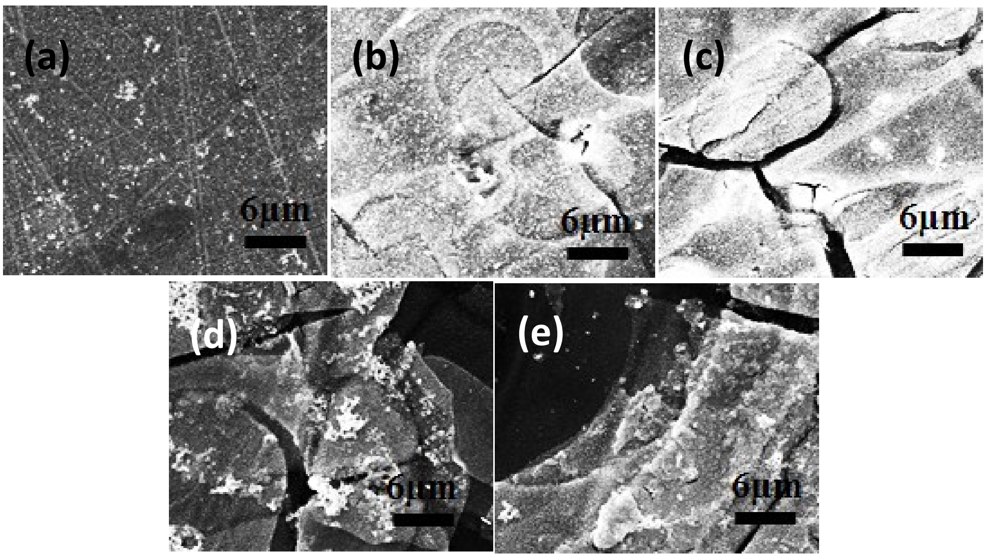

Figure S3 The influence of $\boldsymbol{t_O}$ on the morphology of silver coating (a) 1 h (b) 3 h (c) 5 h (d)7 h (e) 9 h. Note: $\boldsymbol{t_I}$=30min, $\boldsymbol{t_R}$=1h.

Table S2 The influence of t_O on the thickness d, the sheet resistance $R_{\square}$, resistivity ρ of silver coating.

t_O(h)	d(nm)	$R_{\square}$(Ω/sq)	ρ(μΩ·cm)
1	30±3	NC	NC
3	80±8	448.3±2.2	3586.4±53.8
5	100±10	446.8±2.2	4468±67.0
7	110±11	763.9±3.8	8402.9±126.0
9	90±9	NUC	PC

Note: $\rho = R_{\square} \times d$, NUC: Non-uniform conductive, PC: partly conductive

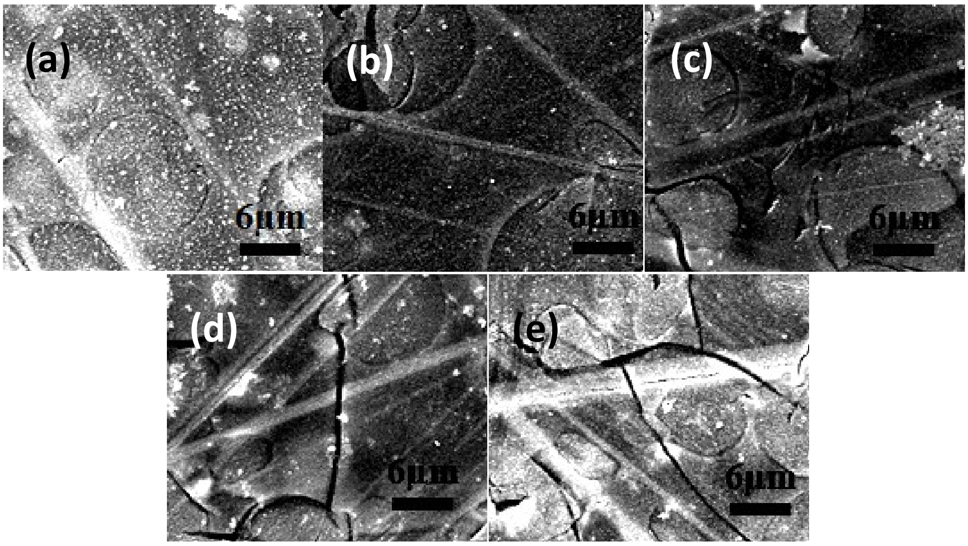

Figure S4 The influence of t_I on the morphology of silver coating (a) 15min (b) 30min (c) 45min (d)60min (e) 75min. Note: t_R=1h.

REFERENCES

1 R. E. Southward and D.W. Thompson, *Adv Mater*, 1999, **12**, 1043.

2 R. E. Southward and D. W. Thompson, *Chem Mater.* 2004, **16**, 1277.

3 G Cui, D Wu, Y Zhao, W Liu and Z Wu, *Acta Mater*, 2013, **61**, 4080.