Electronic Supplementary Material (ESI) for Nanoscale.


# Supplementary Information

## Strong Enhancement of Electrical Conductivity in Two-dimensional Micrometer-sized $RuO_2$ Nanosheets for Flexible Transparent Electrodes

Somi Yoo,‡[a] Jeongmin Kim,‡[a] Hongjae Moon,[a] Se Yun Kim,[b] Dong-su Ko,[c] Weon Ho Shin,[b] Sungwoo Hwang,[b] Doh Won Jung,[b] Soohwan Sul,[c] Chan Kwak,[b] Jong Wook Roh*[b], and Wooyoung Lee*[a]

[a] Department of Materials Science and Engineering Yonsei University, 50 Yonsei-ro, Seodaemoon-gu, Seoul 03722, Republic of Korea

[b] Inorganic Materials Lab, Samsung Advanced Institute of Technology, Samsung Electronics, 130 Samsung-ro, Suwon-si, Gyeonggi-do, 16678, Republic of Korea

[c] Platform Technology Lab, Samsung Advanced Institute of Technology, Samsung Electronics, 130 Samsung-ro, Suwon-si, Gyeonggi-do, 16678, Republic of Korea

**Table S1.** Variations of electrical conductivities according to reducing process.

| Number of layers | Pristine $RuO_2$ NS | Only $NaBH_4$ reduced $RuO_2$ NS | Enhancement of conductivity |
|---|---|---|---|
| 1 layer | 822.9 /Ω·cm | 884.1 /Ω·cm | 7.4% |
| 2 layer | 2097.8 /Ω·cm | 2167.7 /Ω·cm | 3.3% |

**Table S2.** Electrical and optical properties of the LB-deposited films depending on the Ag-doping.

| Sample No. | Condition of LB-deposition and Ag doping | Layer No. | Sheet resistance (Ω/sq) | Optical transmittance (%) |
|---|---|---|---|---|
| Sample 1 | LB-deposition × 4 | 4 | 3231 | 93.4 |
| Sample 2 | (LB-deposition + Ag doping) × 4 | 4 | 1124 | 92.2 |
| Sample 3 | LB-deposition × 2 +Ag doping | 2 | Not measurable | 95.6 |
| Sample 4 | (LB-deposition × 2 +Ag doping) × 2 | 4 | 1509 | 92.8 |
| Sample 5 | LB-deposition × 4 +Ag doping | 4 | 2342 | 92.9 |
| Sample 6 | LB-deposition × 6 +Ag doping | 6 | 1772 | 86.1 |

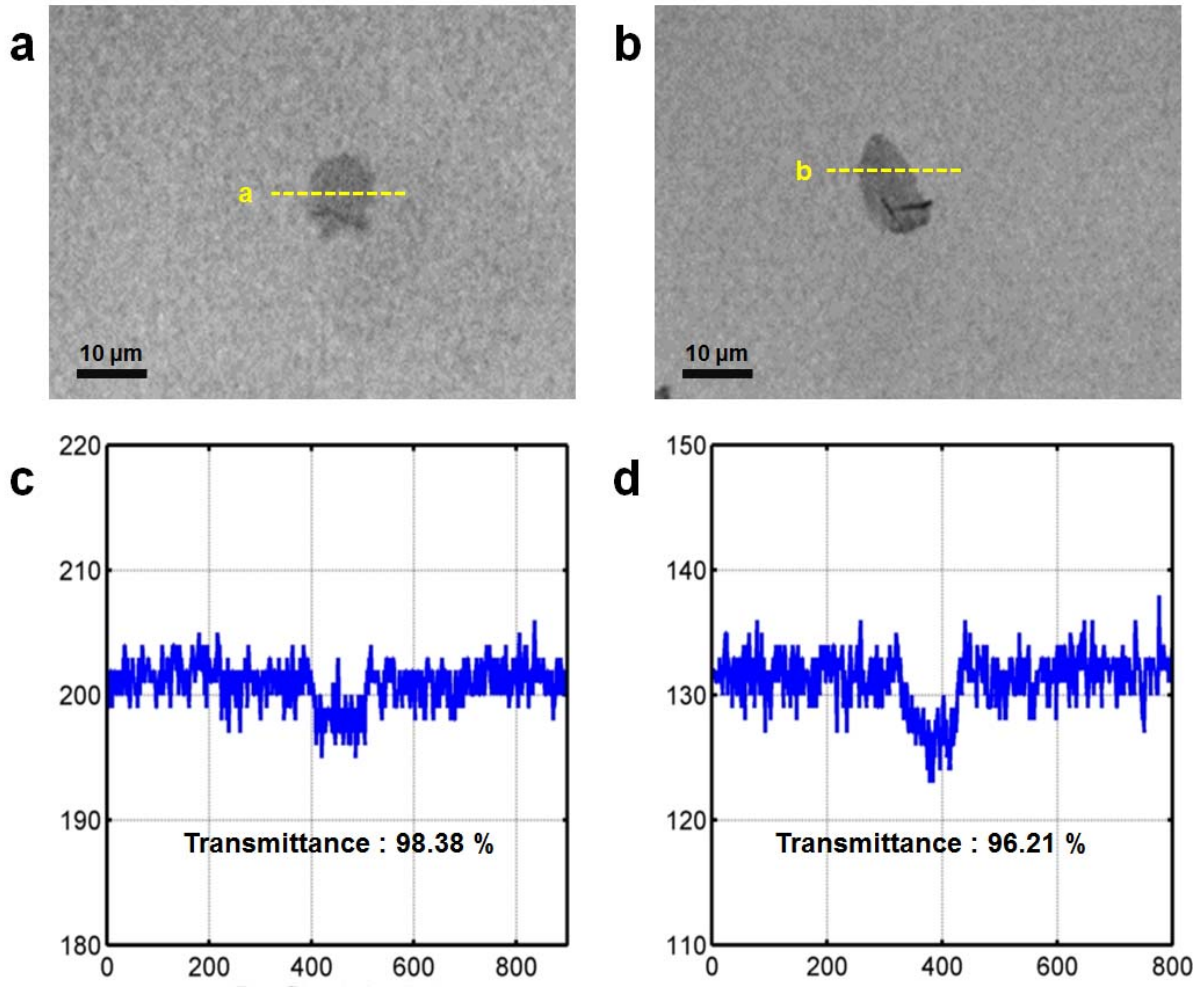


**Fig. S1** Light transmittances of $RuO_2$ NSs. Optical microscope images of (a) monolayer and (b) two-layer $RuO_2$ NS (c), (d) Line profiles showing the total transmitted white light intensities along the yellow dotted lines in (a) and (b), respectively. It should be noted that the transmittances of $RuO_2$ NSs decreased linearly by about 2% with increasing number of layers.

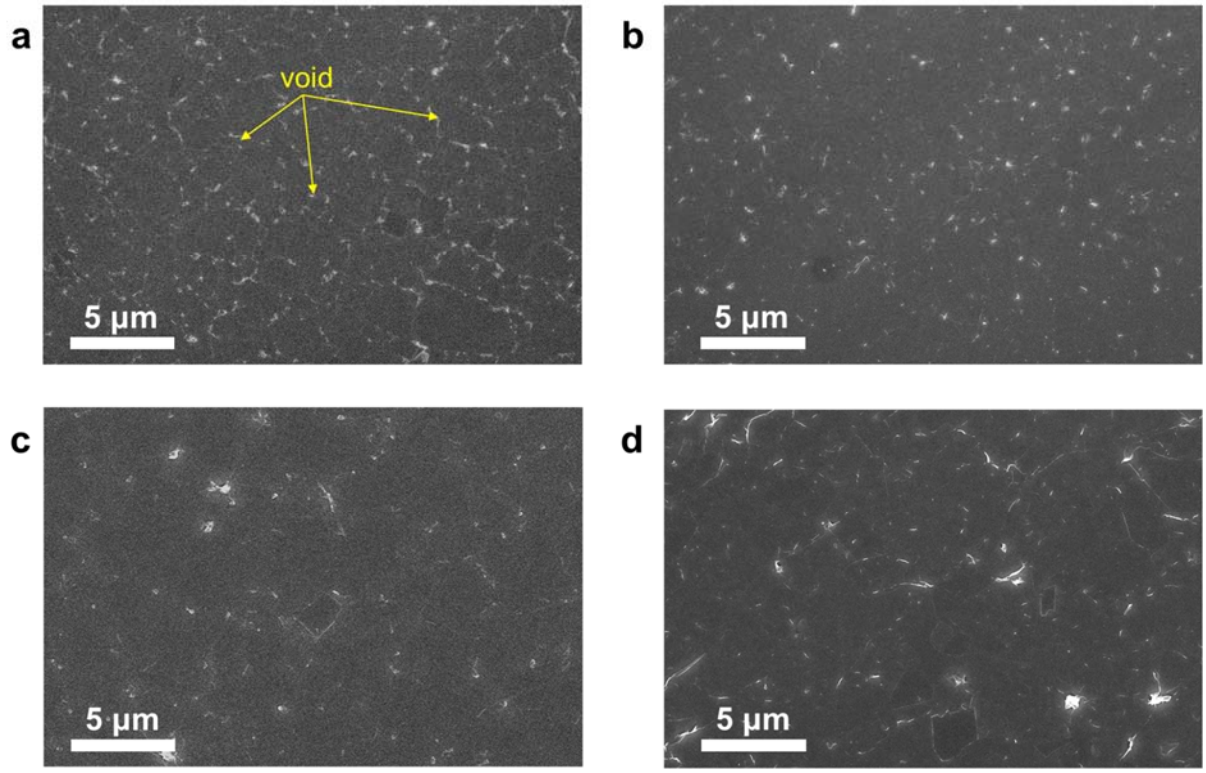


**Fig. S2** SEM image of the surface of Ag-doped $RuO_2$ NSs films with various deposition condition: (a) Just 2 times LB deposition + Ag doping (Sample 3). (b) 2 times LB deposition + Ag doping (2 times repeated, Sample 4). (c) 4 times LB deposition + Ag doping (Sample 5). (d) 6 times LB deposition + Ag doping (Sample 6)

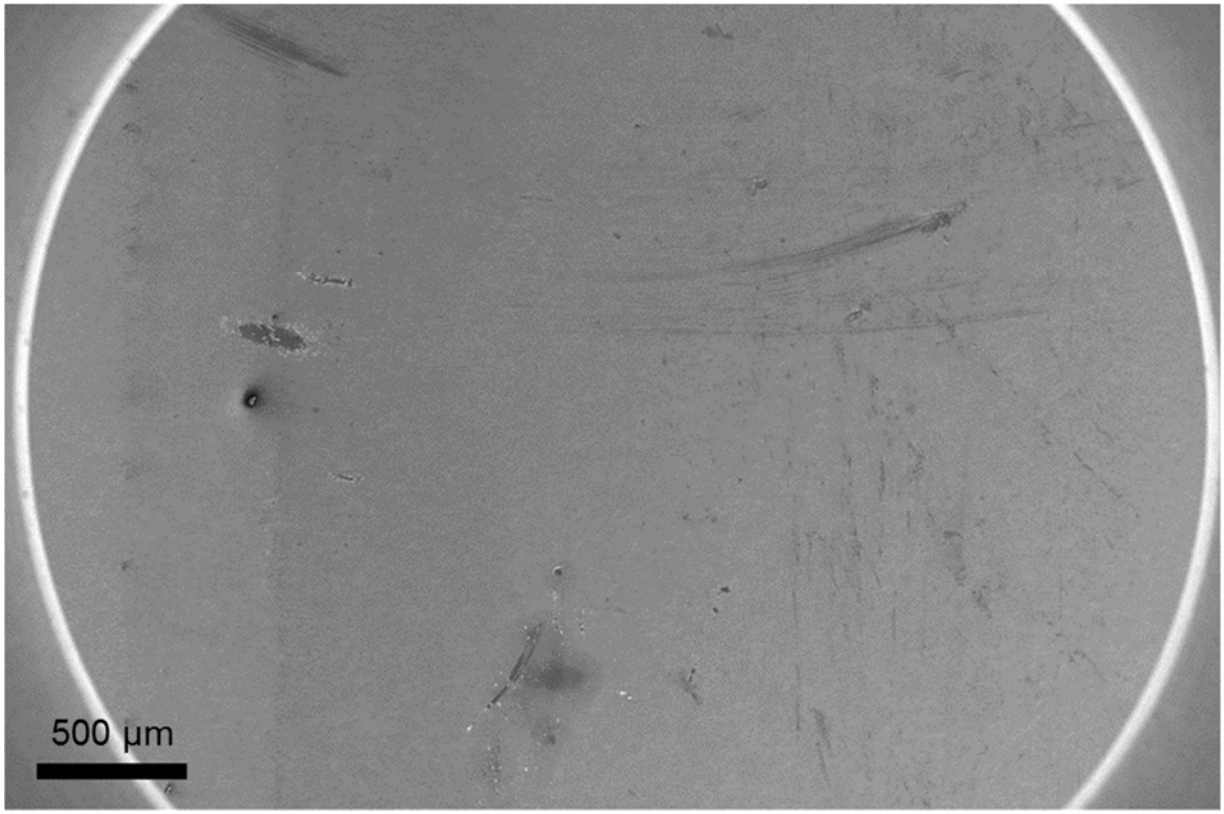


**Fig. S3** Low magnification SEM image of the surface of Ag-doped $RuO_2$ NSs films after 200,000 cycle 1R folding test. The coating of Ag-doped $RuO_2$ NSs in folding area was slightly degraded but the connections of Ag-doped $RuO_2$ NSs were remained.