Supplementary Information

Partially metallized ITO electrodes serve as transparent and foldable conducting-substrates

Noriyuki Takada[*a], *Hajime Okumoto*[a],
Yuka Myoken[b], *Naoto Kamiuchi*[b] *and Keita Sakakibara*[b]

*a. Core Electronics Technology Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, Japan. *E-mail: n-takada@aist.go.jp*
b. Research Institute for Sustainable Chemistry, National Institute of Advanced Industrial Science and Technology (AIST), 3-11-32 Kagamiyama, Higashihiroshima, Hiroshima 739-0046, Japan.

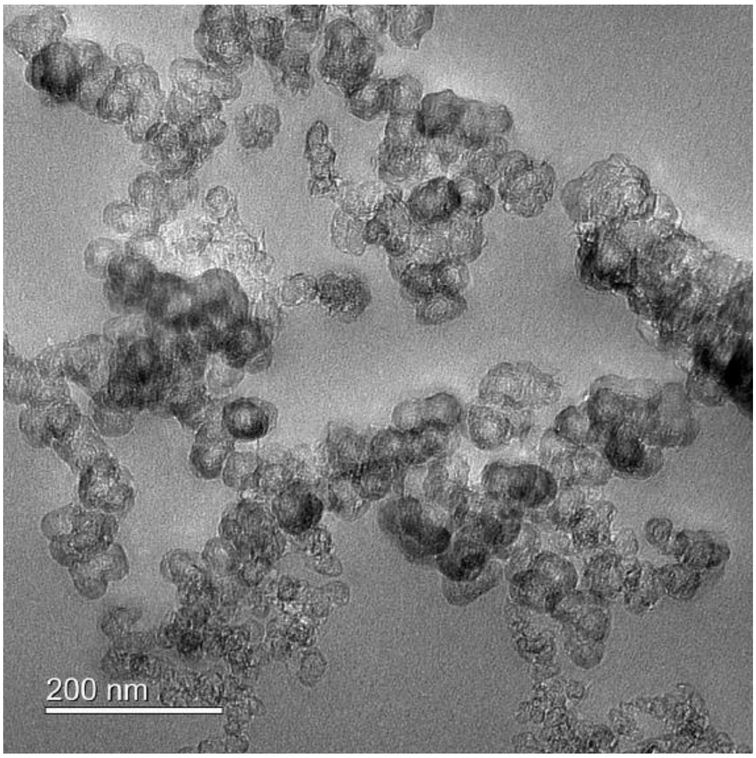

Figure S1

A TEM image of carbon black (ketjen black) nanoparticles in hollow structure of approximately 50nm.

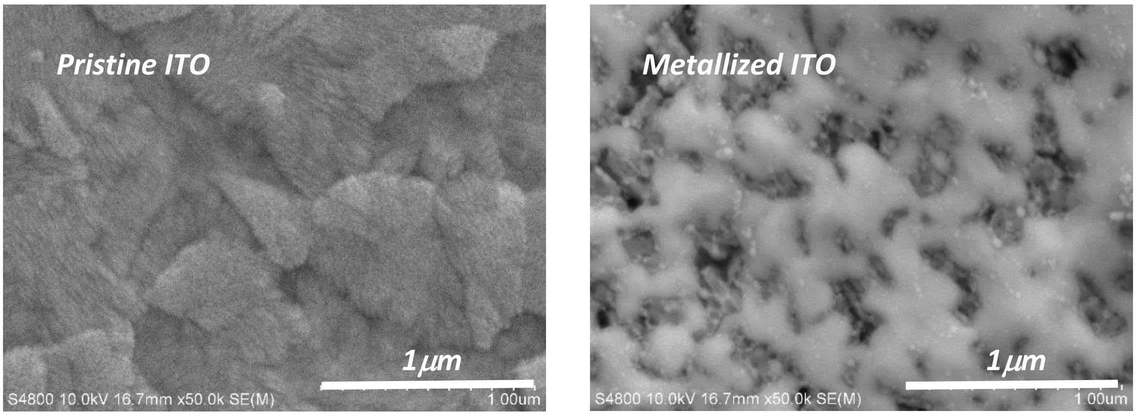

Figure S2

SEM images of pristine ITO and metallized ITO surface.

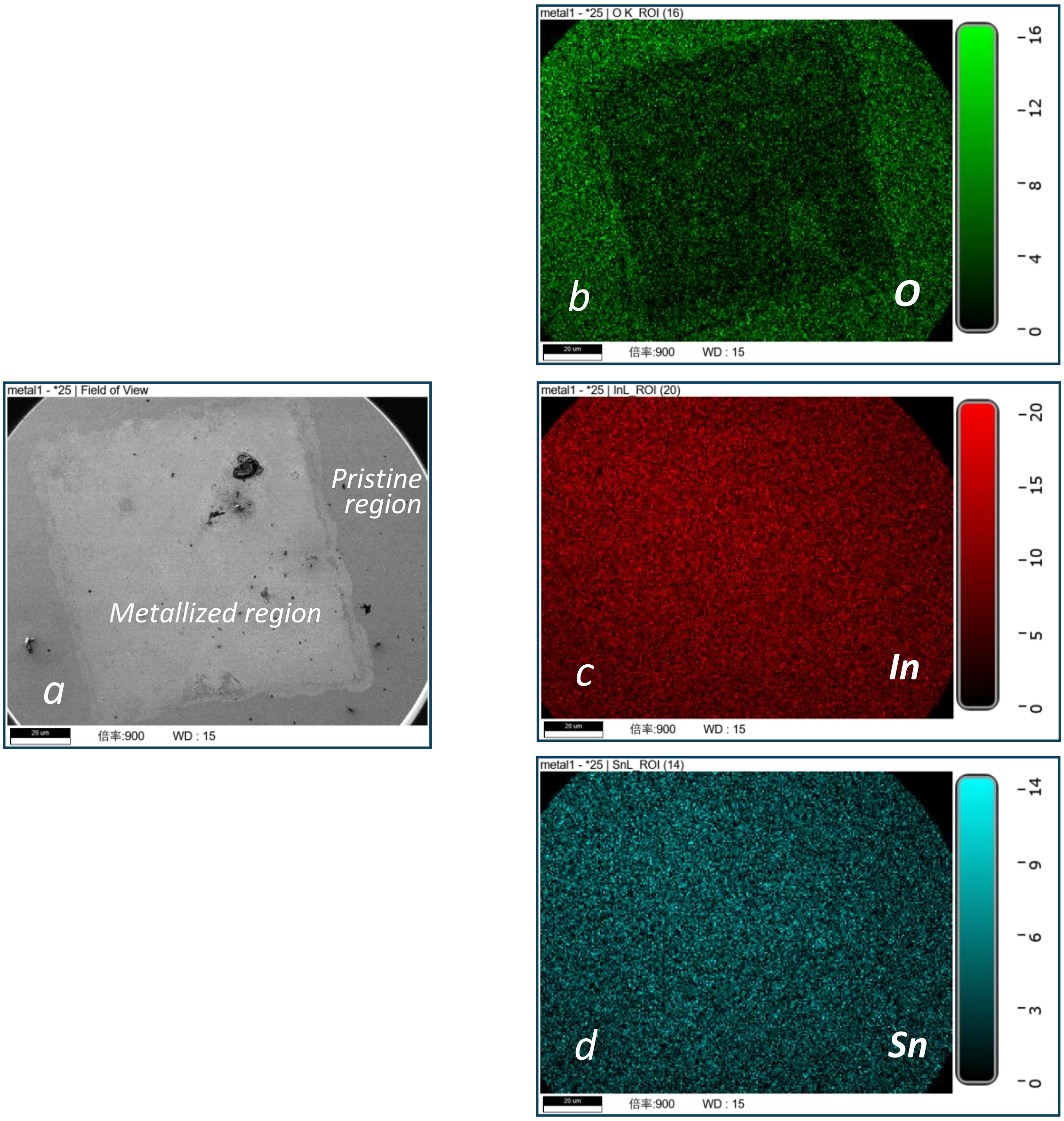

Figure S3

Elemental map of metallized ITO SEM-EDS analysis.

a) a low-magnified SEM image and

b) oxygen, c) indium and d) tin elements.

Calculation S4:
Approximate estimation on the reduction of ITO by protons

The assumptions are: 1) In_2O_3 and SnO_2 are contained in a ratio of 9:1, 2) In_2O_3 and SnO_2 are reduced equally, and 3) *In* and *Sn* metals do not alloy.

[Device area: 5×5mm^2, ***pristine ITO thickness*****: 300*****nm***, ITO density: 7.14g/cm^3]
The subject volume: 0.5×0.5×0.3×10^{-4}=7.50×$10^{-6}$$cm^3$.
∴ Total mass of In_2O_3 and SnO_2: 7.14×(7.50×10^{-6}) =5.355×10^{-5}*g* (= C1)

Next, considering to In_2O_3 : SnO_2 = 9 : 1,

<***Metal Indium***>
[In_2O_3: molar mass: 277.64*g/mol*, density: 7.31g/cm^3]
0.9×C1/277.64=1.736×10^{-7} *mol* --- (=C2)

$\boxed{In_2O_3 + 6H^+ + 6e^- \rightarrow \mathbf{2}In + 3H_2O}$ *metal In* molar mass: 114.82*g/mol*

2×(C2×114.82/7.31)=5.454×10^{-6} cm^3
∴ ***metallic Indium*** *thickness*: 5.454×10^{-6}/0.25=2.182×10^{-5} *cm*=**218.2*nm*.**

<***Metal Tin***>
[SnO_2: molar mass 150.71*g/mol*, density 6.95g/cm^3]
0.1×C1/150.71=3.55×10^{-8} *mol* (=C3)

$\boxed{SnO_2 + 4H^+ + 4e^- \rightarrow Sn + 2H_2O}$ *metal Sn* molar mass: 118.71*g/mol*)

C3×118.71/6.95=6.064×10^{-7} cm^3
∴ ***metal Tin*** *thickness*: 6.064×10^{-7}/0.25=2.43×10^{-6} *cm*=**24.3*nm*.**

Assuming all *300nm* of ITO is reduced, the thickness of ***metal In+Sn*** layer becomes **242.5*nm***.

Therefore, the height-difference between pristine ITO surface and metallized ITO surface is **57.5 *nm*** (=300-242.5).

∴The **20 *nm-step*** (fig.5) observed by the surface profiler means that **104.3 *nm*** (= *d*) of the ITO layer was reduced, considering " *300 : 57.5 = d : 20* ".