Patterned films of ITO nanoparticles fabricated by Ink-jet method

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Abstract

In_2O_3:Sn (known as ITO) thin films possess high optical transparency and good electrical conductivity. Patterned films of ITO nanoparticles by an Ink-jet method on demand printing were conveniently fabricated. The films which were exhibited low electrical resistivity (2×10^{-2} ~ 8×10^{-3} Ω･cm) were obtained. The electrical resistivity of ITO depends on; (1) particle size, size distribution, particle geometry and surfactants, (2) annealing conditions such as temperature and atmosphere.

Introduction

Patterned ITO films have had many applications such as electrodes for flat panel displays, electrodes for solar cells[1] and IR reflective thin films. These films have been usually manufactured by sputtering followed by chemical etching[2]. They have relatively lower resistivity (~10^{-4} Ω･cm); however, they may cause a short circuit due to etching residue[3]. In this work, patterned films of ITO nanoparticles by an Ink-jet method on demand printing were conveniently fabricated. The Ink-jet method can print lines and dots; however, it cannot print small square or rectangular (10 ~ 100μm length and 10 ~100 μm width) patterns. ITO square or rectangular patterned film can be obtained by using a polymer patterned substrate and annealing the ITO sol on the substrate. The film can be used for electrode of displays of cellular phone.

Experiments

We used the ITO nanoparticles which were commercially obtained or synthesized

by spray pyrolysis. The dispersions contained 10~15 % of ITO nanoparticles (diameter ~20 nm) and 10 % of glycerin, water or alcohol was used as solvent. The viscosity of the sol was 5~8 cP. Thin films were produced by spin-coating the dispersion onto quartz glass substrates. The films were annealed at 400 ~ 800 °C in N_2 or air for 1 ~ 2 hours. Resistivity of these thin films was measured by a four-probe technique. The glass substrates with latticed pattern of a hydrophobic polymer were used in order to make square or rectangular patterned ITO films. These substrates were produced by micro-contact printing or photolithography. Perfluoropolymer or polyacrylate were used as the hydrophobic polymer. Dispersion of ITO nanoparticle was dropped onto substrate with the patterned polymer by using Ink-jet patterning equipment (shown in Fig. 1). After that, the substrate was annealed.

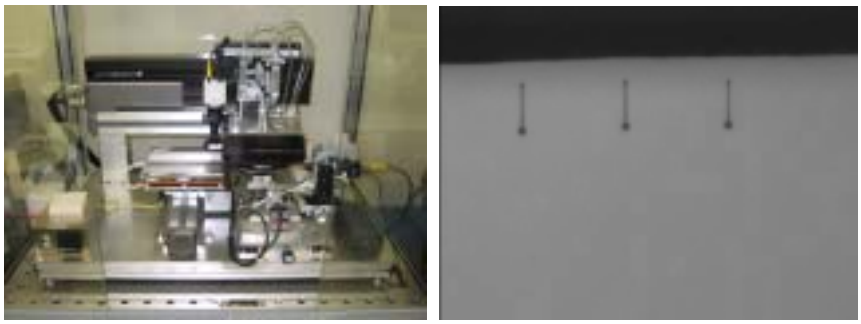
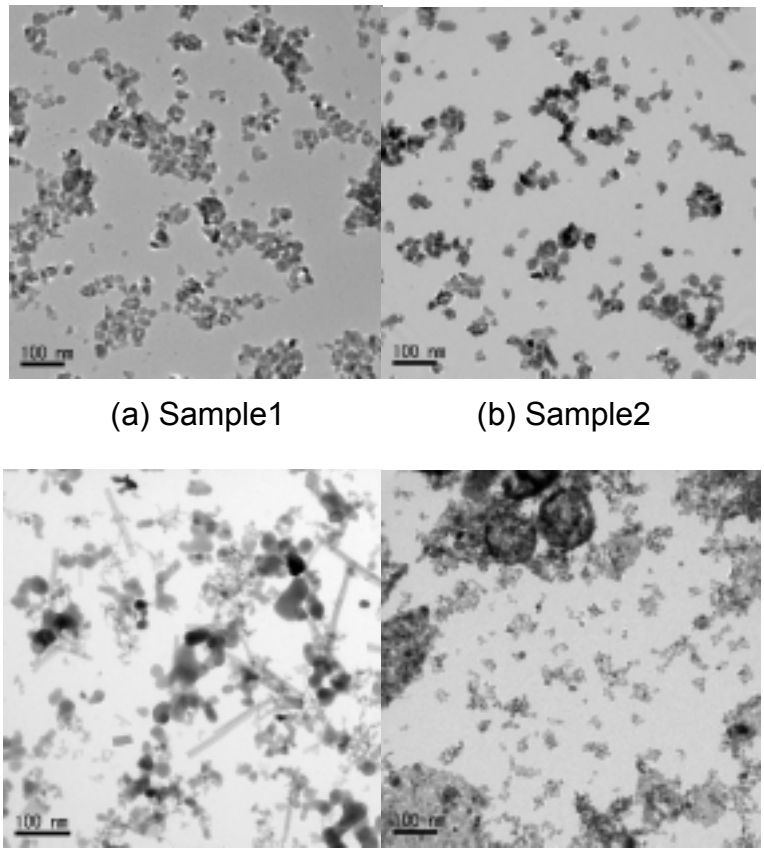


Fig. 1 Picture of Ink-jet patterning equipment and droplets of ITO sol.

Results and discussion

TEM images of different type of ITO nanoparticles are shown in Fig. 2. Thin films of these particles were produced by spin coating. After annealing (at 800 °C in N_2), resistance were measured. The electrical resistivity of ITO depends on particle size, size distribution, particle geometry, and crystallinity. We investigated to produce thin film by using many kinds of ITO nanoparticles. Thin film of smaller nanoparticles has lower resistivity.



(a) Sample1 (b) Sample2

(c) Sample3 (d) Sample4

Fig. 2 TEM images of different type ITO nanoparticles. Each resistivity of thin films is (a) $3.45\times10^{-2}\Omega\cdot cm$, (b) $1.10\times10^{0}\Omega\cdot cm$, (c) $1.68\times10^{-2}\Omega\cdot cm$, (d) $4.78\times10^{-2}\Omega\cdot cm$, respectively.

We produced the patterned ITO films by using the Ink-jet on substrates with the latticed pattern of polymer. The photomicrography of patterned ITO films is shown in Fig. 3. The average thickness of ITO pattern is 1.8 μm.

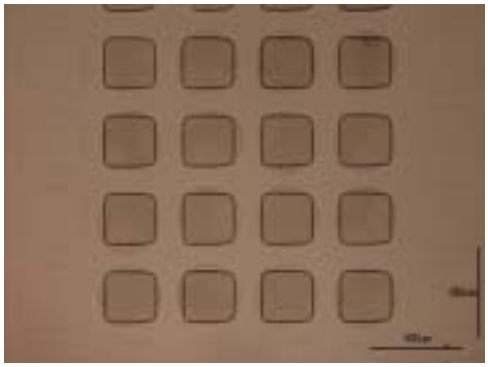


Fig. 3 Photomicrography of patterned ITO films.

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Reference

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