

Transparent Conductive Ultrathin Films with High Flexibility Prepared by Irradiation with UV Light on Metal NPs Monolayer

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ABSTRACT

Indium tin oxide (ITO) as transparent conductive materials has been used in a wide range of applications, however it cannot be used in optoelectronic devices for ultraviolet (UV) or infrared (IR) light because of a lack of transparency in UV and IR regions. Moreover, ITO electrodes, in general, limit their applications in flexible devices due to their inherent brittleness. One of the most successful bottom-up approaches to these problems is the use of metal nano-materials, particularly one- or two-dimensional metal nanowires, due to their high flexibility and transparency of UV, visible and IR light. However, there have been a few reports on the synthesis methods of metal nanowires [1], and the fabrication of conductive films comprised of nanowires is inefficient because large quantities of the nanowires are required to ensure their conductivity. In this study, we show that free-standing conductive Au films with high transparent can be prepared by irradiating with UV light onto Langmuir monolayers of Au nanoparticles (NPs). We also demonstrate that the resulting free-standing Au films can be put on desired substrates and the sheet resistance of the Au films transferred on filter papers has remained almost constant after 100 cycles of the bending test.

Au NPs monolayer were prepared by spreading a chloroform dispersion of dodecanethiol protected Au NPs with ca.4.5 nm diameter. The resulting Au NPs monolayer was blue, and UV light was irradiated on it. We examined the effect of UV light irradiation on the morphology of the NPs monolayer on water. The irradiation with UV light resulted in a considerable morphological change of Au NPs; Au NPs were fused each other in a few minutes, and a gradual progress of the fusion process consequently brought about a complete disappearance of Au NPs and the formation of ultrathin Au films with many tiny holes within 5 min, together with a color change from blue to pale yellow. Here, FT-IR and XPS measurements revealed that UV light caused an oxidative decomposition of dodecanethiol as the protected molecule of Au NPs. Continuous further irradiation with UV light induced a growth of the tiny holes and the formation of nanomesh with dozen nanometers of holes, accompanied by the color change from pale yellow to pale purple. After 20 min there was no significant change in the morphology and color. The ultrathin Au films had a thickness of 3.4 nm, and had a high transmittance of ~80 % in the spectral range of 250-900 nm. The electrical conductivity of the Au films was measured by four-terminal method. The conductivity was 5×10^3 S/cm and kept almost constant values after 100 cycles of the bending test.

REFERENCES

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