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Flexible PET Transparent Conductive Film Based on highly purified Networks of Silver Nanowires

Agharezaei, Hossein[1]; Vahdani, Mohammad Reza[2] Homayoonnia, Giti[1];; Behaein, Saeed[1]

[1] *Department of Physics, Shiraz University, Shiraz*
[2] *Malek-Ashtar University of Technology, Shiraz*

Abstract:

We synthesized silver nanowires (AgNWs) using a polyol process. The flexible transparent conductive AgNWs films were prepared using the spin coating process, in which solution of AgNWs networks were deposited on a polyethylene terephthalate (PET) substrate. Structural properties have been investigated by Edx and SEM. The scanning electron microscopy images show that the AgNWs uniformly distribute on the surface of the PET substrate, which indicates that the AgNWs structure was preserved well after the coating process. Also The SEM analysis revealed that fabricated thin films do not have many defects such as voids and inhomogeneity and smooth surface implies that Ag nanowire network flexible transparent conductive films coated by spin coating could be used as an efficient optoelectronic device.

We use the typical polyol method to synthesize AgNWs networks. Ethylene glycol (EG) was used as both a solvent and a reducing agent, Polyvinyl pyrrolidone (PVP) served as a surface capping agent or anisotropic agent as well as the stabilizer, NaCl and KBr acted as a control agent, and Silver nitrate ($AgNO3$) was used as the silver source. and acetone (PA)was used as the washing solvent. 80 mM $AgNO3$, 0.4 mM KBr and NaCL, 340 mg PVP, were used in polyol process at 160°C. The reaction time was 1 hour. The reaction is expected to take place when the solution is hot. The purification process is very important to obtain pure AgNW networks In order to use for flexible TCF application. there are many nanoparticles and micrometer length rods present along with the nanowires which have to be removed. The as-synthesised solution was kept in room temperature for several hours and then centrifuged with acetone two times at 2000 rpm and 3000 rpm, sequentially. each time the suspension sank to the bottom and the up-solution which remained as supernatant was removed out from the solution. Then, the precipitate was centrifuged at 7000 rpm with ethanol to remove excess solvent, PVP and other impurities in the supernatant. The final precipitate containing nanowires was dispersed in Ethanol and kept for storing.

To make flexible conductive films, we cut PET substrates into slides (2×2 cm). These slides were thoroughly cleaned with detergent and washed with deionized water, sonicated in ethanol for 5min and dried in an oven. A transparent conductive film of the resultant AgNW dispersion was prepared by spin-coating at 2000 rpm on the surface of the substrate. In the spin-coating process,we use 0.4mL AgNW dispersion to spread on the PET substrate. The shematic spin coating process is shown in Figure 1.

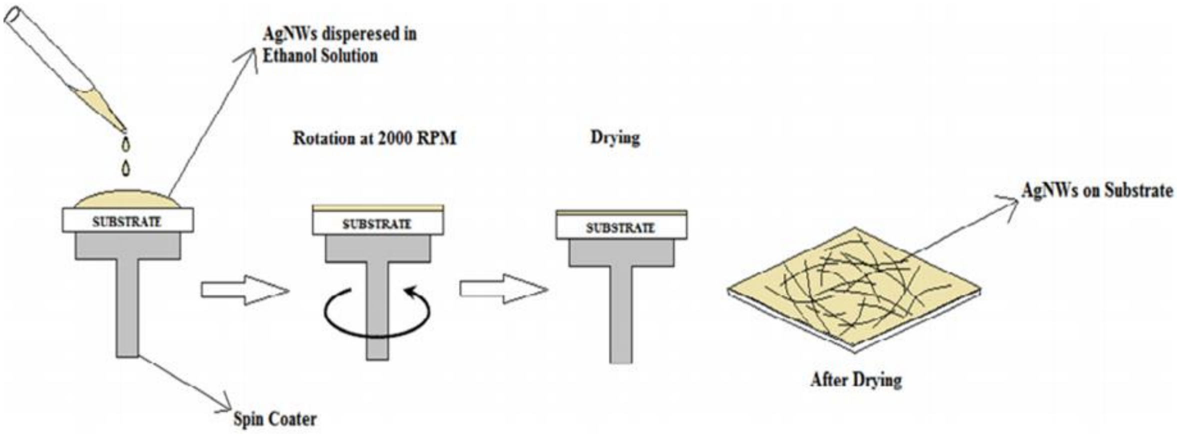

Figure 1. Spin coating shematic[1]

Figure 2 show the Edx graph of AgNW network after purification. It is seen that the as-prepared AgNWs are almost pure silver with a few other elements. As a result, the content of silver is very high after the purification process. Table 2 show the derived data of Edx test. The slight fraction of 29.3% carbon about is very insignificant in comparison with similar works.

Table 1. The data derived from Edx test of AgNW network

	Atomic (%)
C	29/3
O	0/17
Si	66/86
Ag	3/94
Total	100/00

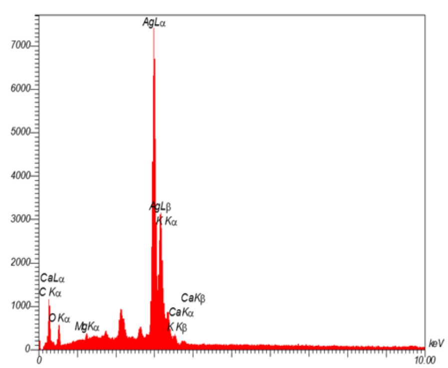

Figure 2. Edx graph of Ag nanowire network after purification

Fgure 3 is the SEM micrograph of AgNW network after purification. The solution of AgNWs was gradually dried in oven at 30 C for SEM analysis. We can see the entangled pure AgNW networks with high aspect ratio which can used well in fabricating flexible TCFs. Finally the electrical properties of the flexible TCF was tested. As shown in figure 4, One 0.06 W LED lamp with series fixed on the surface of AgNWs-PET electrode with conductive adhesive were luminous wich is shown the high conductivity of the fabricated TCFs.

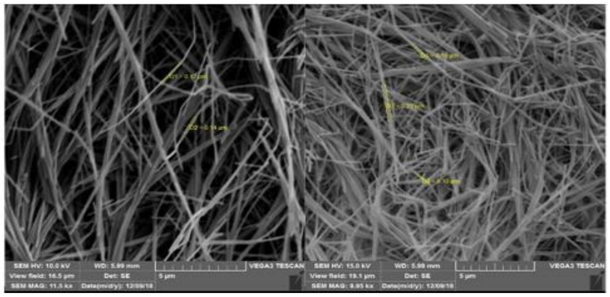

Fig. 3. SEM micrographs of silver nanowires after purification

As can be seen in Figure 4, the most distribution of AGNWs is in the region of 1 to 10 micrometer, as the length of the region increase, the distribution of AgNWs decreased. These data were derived from Digimizer softwere.

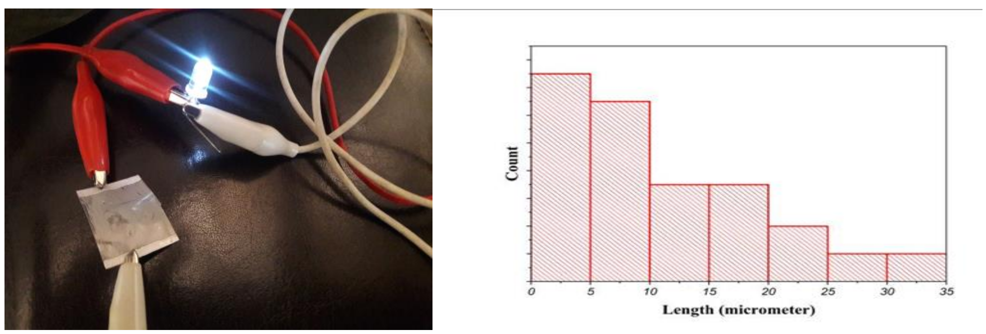

Figure 4. (left): Picture of LED lamp device. (right): distribution of AgNWs on the prepared result

Conclusion:

From this work, we demonstrated the preparation of high yield purified AgNWs from polyol process The SEM images showed that AgNWs of length ~5−30 μm and diameter ~50−80 nm were obtained for the optimized sample. After confirming its highly pure phase by Edx, the sample was coated on the PET substrate and tested its electrical properties which showed that a uniform network of AgNWs on PET substrate having resistance of ~50 Ω/sq. and high conductivity. The resulted coated substrates are capable of bending and folding without any damage to the network, which show their ability to use as transparent conducting flexible films.

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