CHAPTER II

CONDUCTING LAYER OVER CELLULOSE SHEET

1. Deposition of conducting layer of Cellulose sheet.

For the use of CS as a substrate for solar cells it is necessary that cellulose sheet must be deposited with transparent conducting layer. Apart from ITO which is far most the most extensively used conducting layer, we tried of depositing silver nano wires onto the cellulose sheets.

1.1. Synthesis and Deposition of Ag nano wires (AgNW)

Cubical glass container was chosen as reaction vessel. Cellulose Sheet was placed at the bottom of the vessel. Preprepared solution containing 40 ml EG, 1.2 gram PVP and 0.05 g of AgCl (prepared at 170°C) was poured in reaction vessel. Under constant and mild stirring from the top 0.4 g of $AgNO_3$ was added. Formation of AgNW starts. Reaction was allowed to proceed for variable time. Obtained Film was taken out followed by mild washing with deionized water and allowed to dry. The dried film was washed with ethanol and used for further process.

Time of Deposition (minutes)	Sheet resistance (ohm/sq)	Transparency (%)
40	300	90
50	282	83
60	200	81
70	153	76
80	**62**	**71**
90	80	52
100	133	53

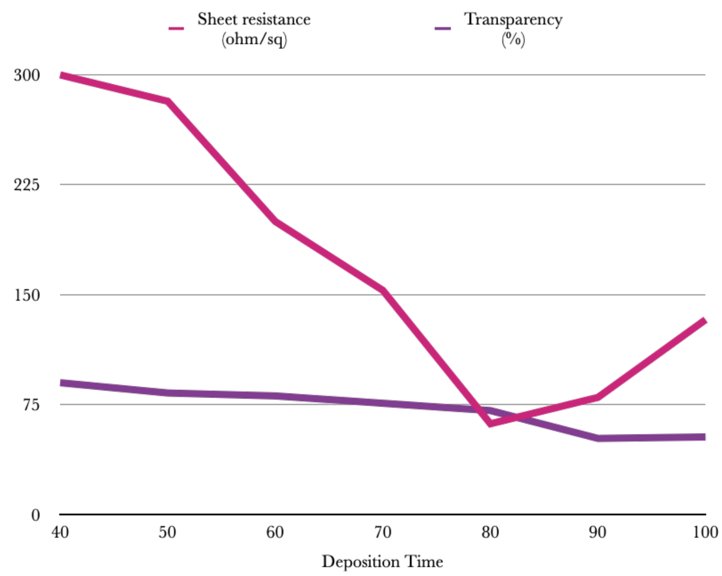

Figure 12: Variation in resistance and transparency with Deposition time

1.2. SPUTTERING OF ITO

ITO was deposited using RF magnetron sputtering at room temperature on BOC Edwards Auto 500 RF. Sputtering target was Indium Tin Oxide slab of 3 inch diameter and 1cm thickness. Composition of target was 90% In_2O_3 and 10%SnO_2. Substrates were mounted on 300 mm stainless steel rotating disk. Distance between target and substrate was 100 mm. The sputtering chamber was evacuated to less than $5{\cdot}10^{-6}$ mbar prior to deposition. High purity argon gas (99.999%) was introduced at rate of 2 sccm. Before deposition, the target was always pre sputtered in argon plasma for 10 min to remove contaminants. No oxygen was added during deposition. The working pressure was maintained at 2×10^{-3} mbar and rf power was 50 W.

Time of Deposition (minutes)	Sheet resistance (ohm/sq)	Transparency (%)
5	83	92.9
10	76	92.1
15	69	91.8
20	52	91.8
25	40	90.6
30	35	89.3
35	23	89.2
40	**16**	**89.1**
50	11	87.9

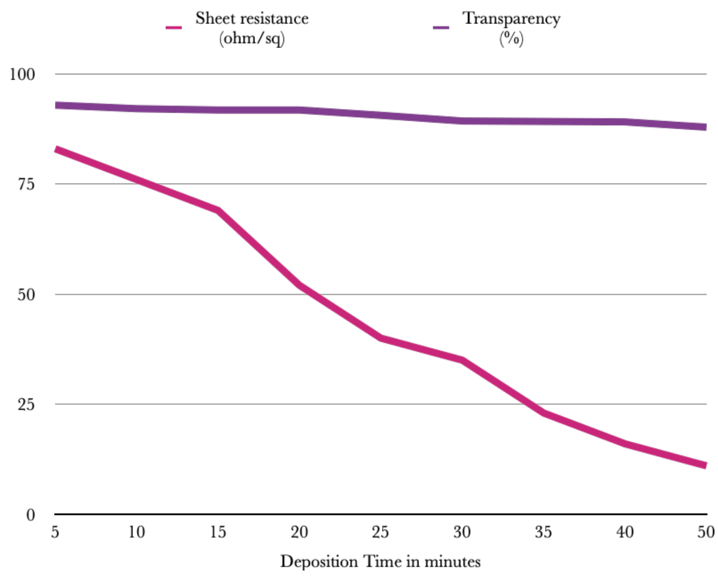

Figure 13: Variation in Transparency and Sheet resistance with Deposition time

The deposition of conductive films is an important aspect of various electronic applications, such as touch screens, solar cells, and displays. In recent years, there has been a growing interest in using silver nanowires (AgNWs) as an alternative to the conventional indium tin oxide (ITO) films due to their high conductivity, flexibility, and transparency. However, the optimization of AgNW deposition parameters is crucial to achieve the desired properties.

The minimum sheet resistance obtained in this study was 62 Ohm/sq, with a transparency of 71%. This result indicates that the AgNW films can achieve reasonable conductivity with acceptable transparency. However, it is important to note that the sheet resistance of ITO films is much lower than that of AgNW films, with a higher transparency. For instance, the ITO deposited films in this study had a sheet resistance of 16 Ohm/sq and a transparency of 89.1%.

Therefore, based on the results obtained, the ITO deposited sheets were chosen for the fabrication of the electronic device. The low sheet resistance and high transparency of the ITO films make them an ideal candidate for various electronic applications.

In conclusion, the optimization of AgNW deposition parameters is crucial to achieve the desired properties of conductivity and transparency. The trade-off between these properties should be carefully considered when selecting the appropriate deposition parameters. The results obtained in this study clearly indicate that ITO films have superior properties compared to AgNW films in terms of conductivity and transparency, making them an ideal candidate for various electronic applications.

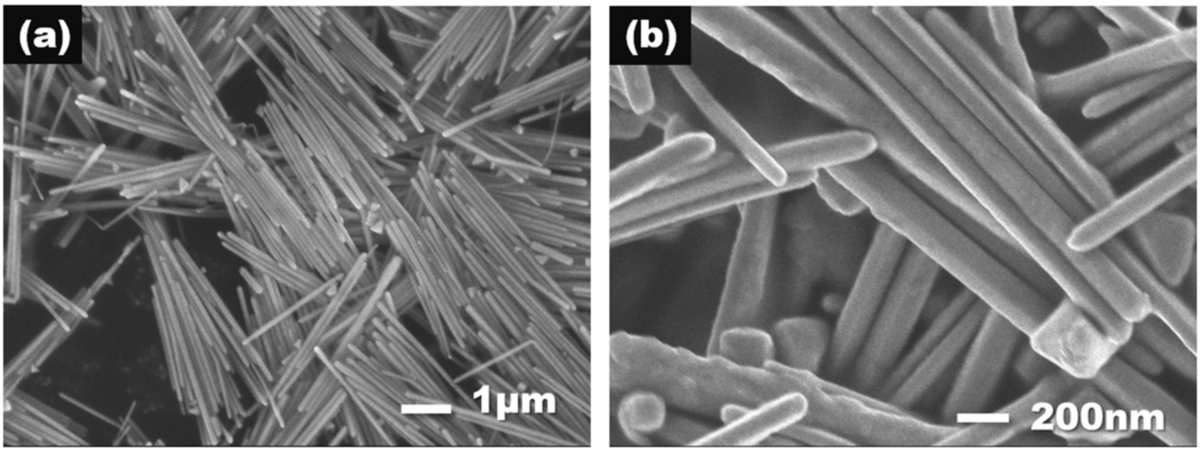

Figure 14: *SEM Images of AgNW (deposition time 80 mins)*

Reason for the increase in the resistance of Ag Nano Wires

In this study, the sheet resistance of AgNW films was investigated as a function of deposition time. As shown in the table, it was observed that after 80 minutes of deposition, the sheet resistance decreased to 62 Ohm/sq, indicating the development of wire continuity. This decrease in resistance can be attributed to the fact that as the concentration of AgNWs increases, the number of wire-to-wire contacts also increases, leading to improved conductivity.

However, after a certain level of deposition, there is an increase in sheet resistance. This increase in resistance, as more Ag nanowires are deposited, can be attributed to various factors. One probable reason is the increase in cross-linking between the wires, leading to an increase in resistance (Wiley et al. 2004, Kim et al. 2013). However, other factors may also contribute to this phenomenon, e.g. the size and morphology of the nanowires can affect their electrical properties, with longer and thinner nanowires exhibiting higher resistance (Nguyen & Youn 2019, Li et al. 2008). Additionally, the presence of capping agents during synthesis, such as polyvinyl pyrrolidone (PVP), can influence the surface roughness and adhesion of the nanowires, thereby impacting their conductivity (Kim et al. 2016). Moreover, the crystallinity and orientation of the nanowires also play a crucial role, as defects and grain boundaries can impede electron transport, resulting in increased resistance (Hauger et al., 2013, Sharma et al. 2022). Furthermore, the density of the nanowire network and the presence of junctions between the nanowires can also contribute to the overall resistance of the network (Kim et al., 2013, Niu et al. 2018, Ji et al. 2014, Kang et al. 2018, Holmér et al. 2018).