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Characterization of Different Type of Backsheet Films Used in PV Modules

Rahul Kumar[1,2], Parag Bhargava[1,2]

[1] *Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology-Bombay, 400076 Mumbai India*

[2] *National Centre for Photovoltaic Research and Education (NCPRE), Indian Institute of Technology Bombay, Powai, 400076 Mumbai India*

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Materials selection is an important factor in the durability of the photovoltaic (PV) module. Backsheet film is critical not only to maintain the performance of the PV modules in a hash environmental but also to ensure the long-term reliability of PV module. The backsheet film serves mainly as potential barrier and provides the necessary environmental protection. The life time of the backsheet film under certain operating conditions directly impacts the performance and lifetime of PV module. The purpose of this investigation is to compare three different type of backsheet films by using various techniques like Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, Thermal gravimetric analysis (TGA) and Broad band dielectric spectrometer.

Keywords: Backsheet material, Structural properities, Thermal stability, Electrical properties

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1. INTRODUCTION

The solar industry faces a challenge in developing photovoltaic (PV) modules that are sufficiently reliable to withstand decades of service in subastral environments with minimal reduction in performance. Over time, the synergistic effect of mechanical stress, moisture, and ultraviolet (UV) radiation degrades protective encapsulation and backsheet structures, particularly their adhesion properties, resulting in debonding and introducing pathways for corrosion and oxidation, ultimately degrading module efficiency [1-2]. Materials selection is an important factor in the durability of photovoltaic (PV) modules in the field. Materials are typically tested under durability conditions that are applied to modules in the IEC 61215 qualification standard [3]. Backsheet is an important part of the PV modules. On the backside of a PV module backsheet films are used. Backsheets are multilayer laminates made from various polymeric materials such as polyvinyl fluoride (PVF) and polyvinylidene fluoride (PVDF) act as a protection against weathering influences, polyesters such as polyethylene terephthalate (PET) provide mechanical strength and inorganic modifiers provide adhesion to the layers. The multilayer structure allows tailoring the optical, thermomechanical, electrical and barrier properties of backsheets according to specific requirements for PV modules [4-5]. Beyond multilayer backsheets described above, co-extruded backsheets are also gaining popularity minimizing interfacial adhesion and separation concerns associated with laminated products. Yet the latest and likely lowest cost backsheets entering into the bill of materials are based on coating technology wherein both the Air and Cell side materials are replaced by a durable fluorinated coatings designated such as CPC or FPF product types wherein letters C and F represent a thin fluoro-polymer coating layer. Many backsheet types are available and can be confusing as to which one to qualify while balancing targeted physical properties, reliability and cost variables [6-7]. In this work, characterization of backsheet films received from three companies (Company-1- Company-3) has been done to compare their structural, thermal, and electrical properties. Raw material characterization is very important to see the quality of the materials it should be done before making the PV modules.

2. MATERIALS AND METHODS

Different type of backsheet films (Company-1- Company-3) was characterized by FTIR spectroscopy, TGA and Broadband dielectric spectrometer. FTIR spectra of backsheet film was measured by using using a Nicolet 5700 spectrometer. Thermo-gravimetric analysis of backsheet films was done by using SDTA 851Metter-Toledo-star system in the temperature range from 20 °C to 500 °C. Electrical properties of backsheet films were measured using broadband dielectric spectrometer (Novo control technologies Germany, Concept 80) at 10 Hz in the temperature range of -35 °C to 100 °C.

3. RESULTS AND DISCUSSION

Structural analysis of backsheet films was done by using FTIR spectroscopy as shown in Fig. 1. FTIR analysis shows that all the three grades of backsheet films have same material towards cell side while the material towards outside is different. It means that all the three grades backsheet films are made by different polymers as shown in Fig. 1. Three different grades of back sheet films were characterized by thermal gravimetric analysis (TGA) to identify the thermal stability of the backsheet film material. Thermo-gravimetric analysis (TGA) of backsheet films (Company-1- Company-3) was done in the temperature range from 20 °C to 550 °C as shown in Fig. 3. The heating rate was 10 °C/min during the experiment. Backsheet film received from company-1 shows thermal stability up to 440 °C, while backsheet film received from company-2 and company-3 shows that stability up to 410°C and 350 °C respectively. TGA results show that backsheet film received from company-1 is relatively stable than backsheet fims received from company-2 and company-

3. It was observed that all the three gardes of backsheet films were made by different polymers as shown in Fig. 1 and thermal stability of the backsheet films are different.

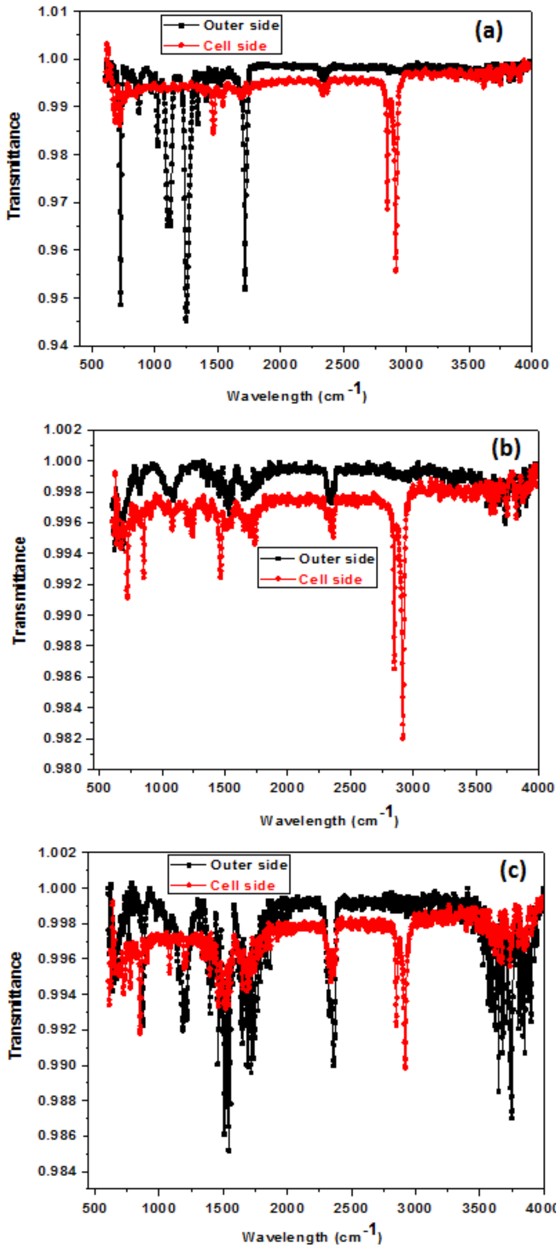

Fig. 1 – FTIR spectra of backsheet film (a-Company-1, b-Company-2, and c- Company-3)

Volume resistivity studies are very important for insulating materials, because the most desirable characteristic of an insulator is its ability to resist the leakage of electrical current. Volume resistivity is an intrinsic property of the insulating material [8]. Volume resistivity and dielectric constant of backsheet films (Company-1-Company-3) were measured by Broadband dielectric spectrometer.

Volume resistivity of backsheet films was measured at frequency of 57 Hz in the temperature range of – 35 °C to 180 °C as shown in Fig. 3. Fig. 3 compares the volume resistivity as a function of temperature. It was observed that initially volume resistivity of backsheet

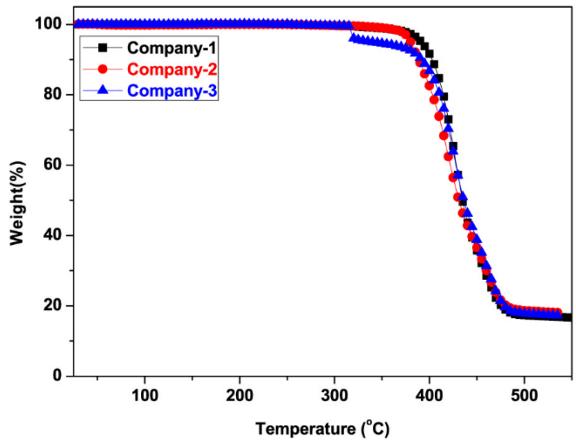

Fig. 2 – Thermo gravimetric analysis (TGA) of backsheet film (Company-1- Company-3)

films received from three companies (Company-1-Company-3) increases with the temperature. Volume resistivity of backsheet film received from Company-1 increases in the temperature range of – 30 °C to 10 °C, after this it is almost constant from 10 °C to 20 °C and then drastically increase with increasing temperature up to 65 °C and then drastically decrease with increasing temperature. Volume resistivity of backsheet film received from Company-2 increases in the temperature range of – 30 °C to 65 °C and then decrease with increasing temperature. Volume resistivity of backsheet film received from Company-3 increases in the temperature range of 30 °C to 30 °C and then decreases drastically with increasing temperature. Fig. 4 shows the volume resistivity of the backsheet film vs frequency and it was measured at constant temperature of 30 °C.This measurement also indicates that volume resistivity of backsheet film received from Company-1 is higher than Company-2 and Company-3 respectively. Volume resistivity of backsheet film should be high (10^{14} ohm-cm) for PV application. Volume resistivity measurements suggest that backsheet film received from Company-1 is relatively better than backsheet films received from Company-2 and Company-3 respectively.

The ability of any material to store electric charge refers to dielectric constant. The dielectric constant of a materials arises due to polarization of molecules and usually the dielectric constant increases with increase in polarizability [9]. Dielectric constant of backsheet films was measured at temperature of 30 °C in the frequency range of 10 Hz to 10^7 Hz as shown in Fig. 5. It was observed that that dielectric constant of backsheet received from three companies (Company-1-Company-3) is almost constant in the frequency range of 10^1 to 10^4 Hz, the dielectric constant consists of orientation, atomic and electronic polarization, respectively. Here, the dispersion region spreads over a wide range of frequencies. Dielectric constant of backsheet (Company-1-Company-3) decreases at high frequency in the range of 10^5 to 10^7 Hz. Above ~ 10^5 Hz, the decrease in dielectric constant of backsheet films (Company-1-Company-3) with increasing frequency is assumed due to the drop in orientation polarization [10]

Backsheet film received from Company-1 has lower dielectric constant ~ 2.50 than backsheet films received from Company-2 and Company-3 (dielectric constant ~ 2.76 and 2.82). Dielectric constant measurements show that backsheet film received from Company-1 is relatively better than backsheet films received from Company-2 and Company-3 respectively.

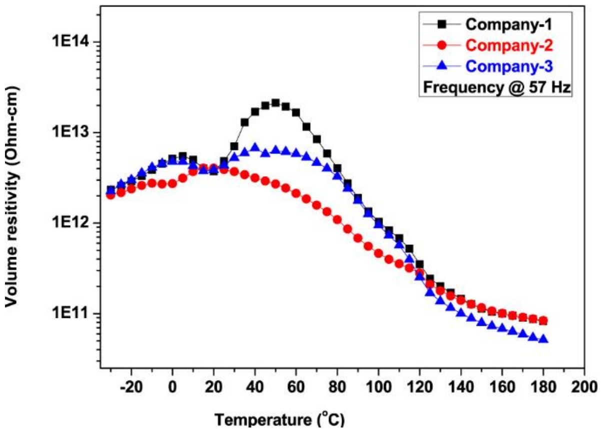

Fig.3. – Volume resistivity of backsheet film vs temperature (Company-1- Company-3)

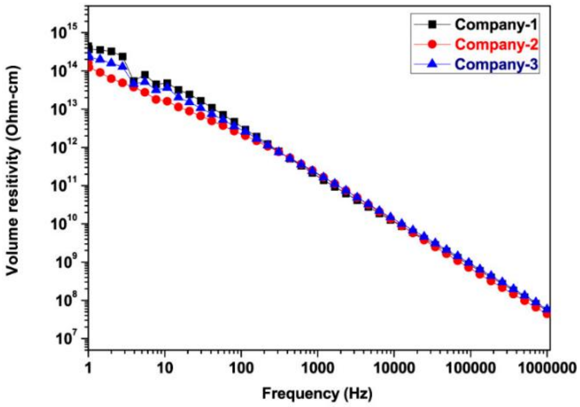

Fig.4. – Volume resistivity of backsheet film vs frequency (Company-1- Company-3)

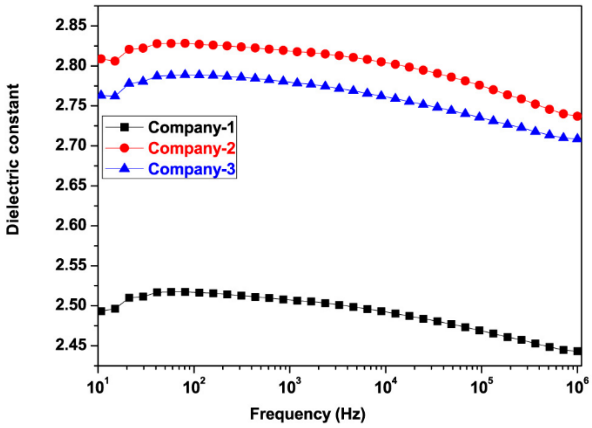

Fig.5. – Dielectric constant of backsheet film vs frequency (Company-1- Company-3)

Figure 6 shows the dielectric loss of the backsheet film vs frequency. It was observed that dielectric loss increases with increasing frequency, which can be attributed to the reason that interfacial polarization and orientation polarization of dipoles cannot follow with external electric field gradually and therefore leads to the decrease of dielectric constant and increase of loss [11].

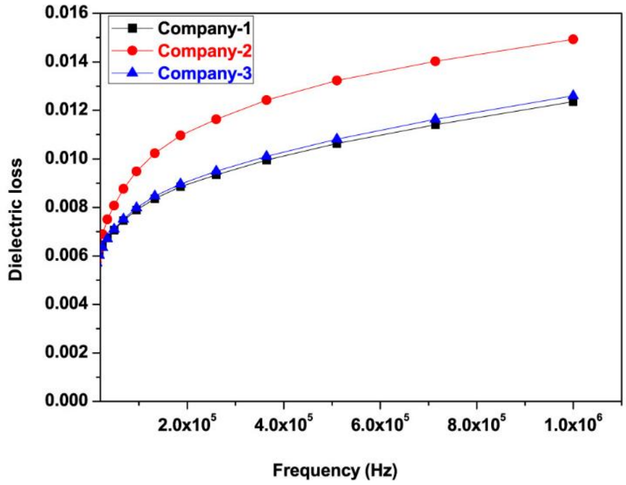

Fig.6. – Dielectric loss of back sheet film vs frequency (Company-1- Company-3)

Backsheet film received from Company-1 has low loss dielectric loss relative to backsheet films received from Company-2 and Company-3 respectively.

4. CONCLUSIONS

Backsheet films received from three companies (Company-1- Company-3) were characterized by various techniques like Fourier-transform infrared spectroscopy (FTIR), Thermal gravimetric analysis (TGA) and Broad band dielectric spectrometer to compare their structural, thermal and electrical properties. Thermal, and electrical characterization show that backsheet film received from Company-1 is relatively better than backsheet films received from Company-2 and Company-3.

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