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PERFORMANCE COMPARISON AND OUTDOOR MONITORING OF SMOOTH AND TEXTURED COVER GLASS FOR SOLAR MODULES OF UP 6 YEARS EXPOSED

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INFOS SUR L'A R T I C L E

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A B S T R A C T

Solar modules are being built with nearly the same configuration for decades now. The front is covered with a tempered glass pane. The performance of a PV module can be increased by the texturation of the front side. One of the major requirements for front cover glasses is their high optical transmission. One option to boost transmission is texturing the front surface in a similar manner to crystalline solar cell. Another advantage of a textured glass is the fact that the reflected light beam at normal incidence has a second chance of being transmitted to the solar cell. Furthemore, the texturation of front cover glass might collect more dust and soiling than a flat glass surface. Due to this concern, the soiling effect of module covered with textured cover Alberino P glass after long-term exposed will investigated in this work. The modules presented in this work have the same characteristics in STC (i.e short circuit current, open circuit voltage and maximum power point). Electroluminescence, I-V and P-V characteristic are the method used to detect faults on the PV module. The results show a loss of PV performance with textured cover glass is 1,72% higher than the reference module in other hand the increase of serie resistance is also observed in both modules.

I. INTRODUCTION

Photovoltaic technology penetration is experiencing noticeable progress. However, it's performance is significantly affected by soiling, which is influenced by several factors such as site characteristics, weather, tilt angle and surface orientation, surface material and dust properties, and PV surface materials (Chanchangi et al., 2020a).

The electrical output of solar PV panels is reduced by two main factors: a reflection of light at the air-glass interface and scattering of light due to soiling. Reflections occur because of the abrupt change in in refractive index between air (n=1) and glass (n=1.5). textured glass is a possible means for reflection reduction of photovoltaic modules. Texturing not only increases the energy yield of the system through reduced reflection losses, but also can play a role in dissipating waste heat by enhancing convective and radiative heat loss (Zhou et al., 2020)

However, the severity of the problem may differ from one surface to another. There are differnts types of PV module cover glass:

- flat, no anti-reflective coating glass
- flat with antireflective coating glass
- textured-A 500-AR glass
- Textured-B- 500 glass
- Textured-1000 glass
- 500*500 ALB-AR

Grunow et al., (2005) investigate the influence of different surface textures on the energy rating of the module, they noticed that an increase of 3,5%, 2% improvement in energy yield of pyramids textured and weake textured glass. (Piliougine et al., 2008) investigated the dust loss in photovoltaic modules with different cover glasses, their results indicated that the loss due to accumulated dirt in the module can reach value of about 15% for periods without of rain. (Blieske et al., 2008), (*Nositschka: Sun-light harvesting with surface patterned... - Google Scholar*, s. d.) examined the impact of the textured glass cover on the back surface temperature, light transmission, and power output of PV modules in USA. Their indoor testing showed that the textured surfaces yield a noticeable increase in light transmission compared to the flat surface while the outdoor exposing indicated an increase in Isc of up to 3,5% depending on the type of glass texturing. (Duell et al., 2010) investigated the impact of textured glass on light transmission. They found a 3,2% for pyramid with normally incidence light.

Scattering dust decreases the direct component of solar radiation (Denholme, 2010), hence increase the diffuse irradiance component. The soiling is a phenomenon influenced by location-based meteorological factors and climatic conditions, tilt angle (Lopez ,2016). Dust is one of the most common causes of reduced PV module performance. In general, dust deposition decreases PV module performance (Chaichan & Kazem, 2020; Chanchangi et al., 2020b; Xu et al., 2020). Another study claimed that, the effect of dust might reduce the PV performance with about 98% of short circuit-current (Chanchangi et al., 2020a).

The average degradation performance of PV module due to dust deposition is relatively high in Africa and MENA. (Ndiaye et al., 2013) studies the impact of dust in PV module in Senegal (Africa). They find a maximal power loss that reach 20 to 80% with a flat glass after one-year exposition. The performance power loss in Saoudi Arabia due to deposit dust on the PV is higher than 50% (Adinoyi & Said, 2013). However, the severity of the problem varies and glass cover dependent.

A major concern to PV-system end-users is that the texture of the cover glass surface might collect more dust than a flat glass surface (Blieske 2013). (Said et al., 2015) assessed clean modules covered with an antireflective coating and confirms that dust accumulation can lead to a drastic reduction in PV module power output (a 10-17% reduction) after six weeks of exposure without cleaning.

Most of these works highlight the short-term impact of the dust in textured surface cover glass. Also, they are controlled with the seasonal effect. These study apexes the long-term effects of the dust in the textured surface cover glass without maintenance.

1-1-Glazing characteristics

The dust accumulation on PV panels varies with the property of the panel surface. The textured surface or glass textured in the front side and the additional coating on the PV panels comprise the surface property. The dust accumulation on the textured surface is higher than the plan surface. The textured panels have rough and irregular surfaces increase the soiling on the panel surface. (Zaihidee 2016).

1-2-Environmental conditions

The environmental effects on soiling arise from the variations in atmospheric and climatic conditions. The air bonne dust concentration, probability of dust storm, the occurrence of dew, rainfall, volcanic eruptions, etc contribute to the soiling of PV panels.

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II. EXPERIMENTAL METHOD

To evaluate the performance, 2 crystalline silicone PV was subjected in a long term exposed for more than 5 years without cleaning see fig.1.

Fig.1. :The system of photovoltaics modules: textured and no textured

The system was composed by modules produced by the same manufacturer. The test facility in this study is located in Cologne (Germany). Non destructive diagnostic including I-V curve, P-V curve, electroluminescence (EL) are employed to assess PV performance and compare the impact of soiling on the textured module up of 6 years exposure. The characteristics of each module is given by the table1.

Table 1: Characteristics of modules

Power (Pmax)	240
Open circuit voltage (Voc)	36,72
Short circuit current (Isc)	8,74
Voltage at maximum power (Vmp)	28,89
Current at maximum power (Imp)	8,31
Permissible system voltage	1000VDC
Maximum reverse current	
Application class	A

III. RESULTS

The standard procedure to take into account for the effect of a changing incident angle on the short circuit current of a module (from 0° to 90° with respect to normal incidence of 0°) is applying the so-called incidence angle modifier (IAM). They provide correction factors for device short circuit current Isc for incidence angle β. It is defined as the ratio of the short circuit current measured at an angle of incidence and the short circuit current at perpendicular incidence. The value of corrected by cosines to eliminate the cosine effect and to keep all other angular effects.

To include the influence of a changing solar spectrum, it is common to derive a correction factor (K), which depends on the air mass that the light needs to traverse before hitting the (incomplete sentence).

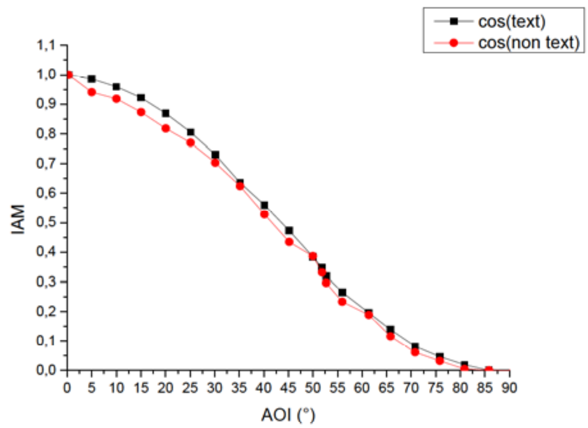

Fig.2. *IAM with direct radiance comparison between textured to no texture. Correction factor K_{am} for flat glass and textured surface* glass

3.1. Electroluminescence imaging

The elctroluminescence of both modules show no defect on both modules (fig. 3). This result shows that, the severity of environemental conditions are minimizing on the cells of the module.

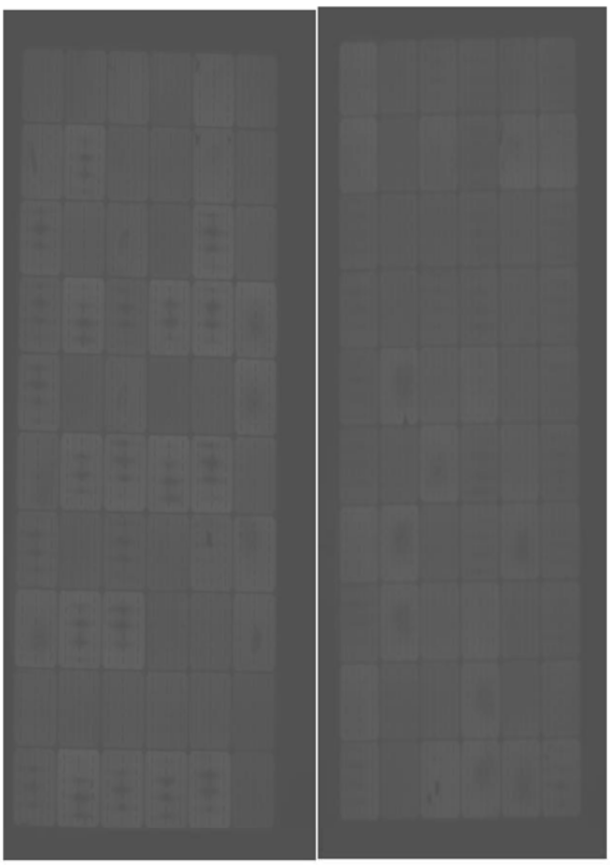

Fig.3. *Electroluminescence imaging of the two modules: (a) float glass PV and (b) textured glass PV*

3.2. Comparison of performance loss comparison of flat and textured glass

The I-V characteristics of the textured and no textured modules are presented in figures 4 and 5. They show that, the open circuit-voltage has not degraded, it's the same of the both modules. The short-circuit current of the reference module is higher to short-circuit current of the textured module. This can be due to dust on the textured module, thus, the dust can decrease the light trapping on the module hence, the short circuit current. The global degradation losses of short-circuit current of the textured module is 2,25% then the reference module

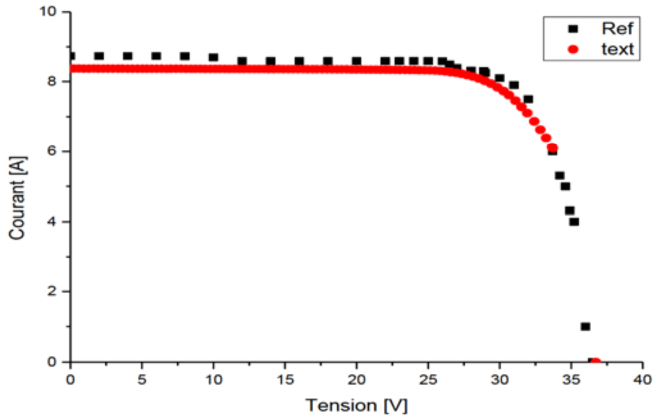

Fig.4. *Characteristic I-V of the module textured*

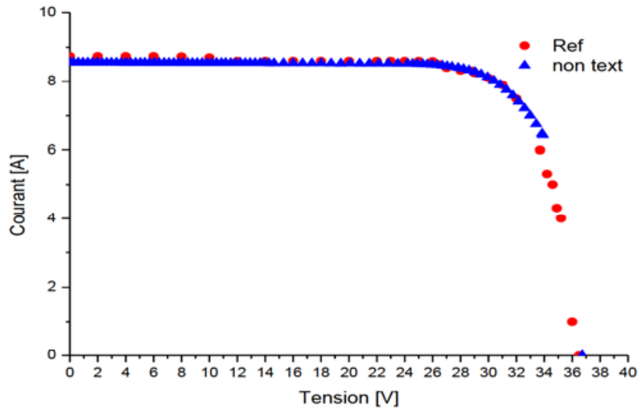

Fig.5. *Characteristic I-V of the module no textured*

The table2 shows different performance parameters losses after up 6 years' exposure of the module of flat glass then the reference module.

Table 2: *Performance parameters losses after up 6 years' exposure of the module of flat glass then the reference module*

DGIsc	1,830663616
TADIcc (%)/an	0,366132723
DGPmax (%)	7,8125
TADPmax(%)/an	1,5625
DGIm (%)	4,31
TADIm (%)/an	0,86

3.3. Comparison of performance loss comparison of flat and textured glass

As seen in figures 6 and 7, after normalized I-V and P-V curves, the soiling on the texturation have sensibely the same impact (increase serie resistance et decrease of shunt resistance) in the both modules.

The results of I-V curves show power loss of the textured and no textured PV modules. The global degradation of the short circuit current is respectively 4,34% and 2,05% for textured and no textured module. The global degradation rate of the power loss is respectively 0,89. % and 0,91% for no textured and textured. The results show that the texture of the cover glass surface might collect more dust than a flat glass surface (Blieske, 2013). The performance losses of the textured cover glass is 2,24% higher than the flat module. The value is mainly dependent upon the weather conditions and orientation of the module.

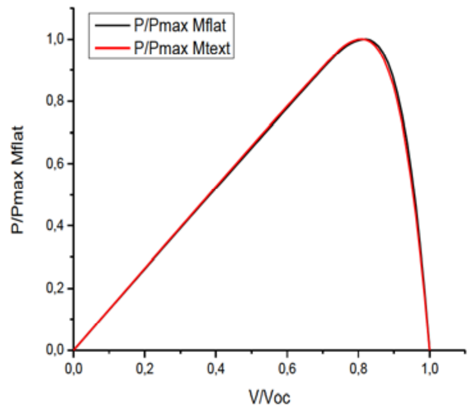

Fig.6. *I-V and P-V curves normalized of the modules*

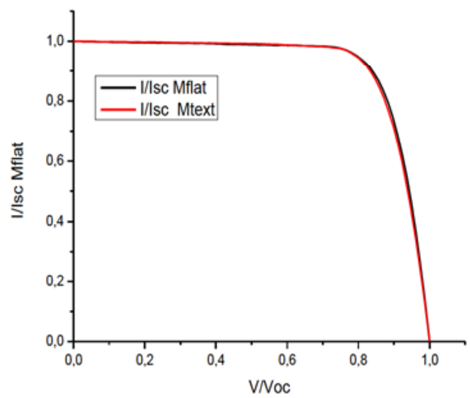

Fig.7. *Characteristic I-V of the module textured and no textured*

IV. CONCLUSION

The modules presented in this work have the same characteristics in STC (i.e short circuit current, open circuit voltage and maximum power point). Electroluminescence, I-V and P-V characteristic are the method used to detect faults on the PV module. The results show a loss of PV performance with textured cover glass is 1,72% higher than the reference module.

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