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Research on Potential Induced Degradation (PID) of PV Modules in Different Typical Climate Regions

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Abstract. Potential Induced Degradation (PID) is one of the most important factors effecting the performances of Photovoltaic (PV) modules and PV systems in recent years. In this paper the PID phenomena of the PV power plant in different typical climate regions were studied and some experimental PID simulations were carried out in order to find out the factors effecting the performance by PID. The results show that the typical PID phenomena are easy to occur in cells close to the border of the PV module. PID phenomena can appear in PV power plants under different climate conditions, but the effecting degrees on module performance are different depending on temperature, humidity and other parameters. We also find the maximum power would recover in some degree after positive-bias voltage duration.

1. Introduction

Photovoltaic (PV) module, the core component of PV power generation system, may have output power degradation phenomenon. In the application, degradation in parts of PV module has far exceeded the manufacturer's commitment value. Preliminary studies have shown that one of the main factors of this abnormal degradation is due to potential induced degradation (PID) [1-4]. There are many factors that affect the PID effect of PV modules. The internal factors include the materials and production process used in PV modules. External factors include the actual environmental conditions of PV modules [5]. It is known that the climatic conditions in different regions have a great influence on the PID effect of PV module, and even if the same PV modules are used in different climatic conditions, the degree of PID effect shows great differences according to the observation and detection data of PV system under different climatic conditions.

In order to understand the influence of external factors on PID effect of PV modules, this paper studies the occurrence of PID in PV modules in different typical climate regions, and analyzes the influence of external factors on the PID effect of PV modules in combination with laboratory simulation tests.

2. Experimental

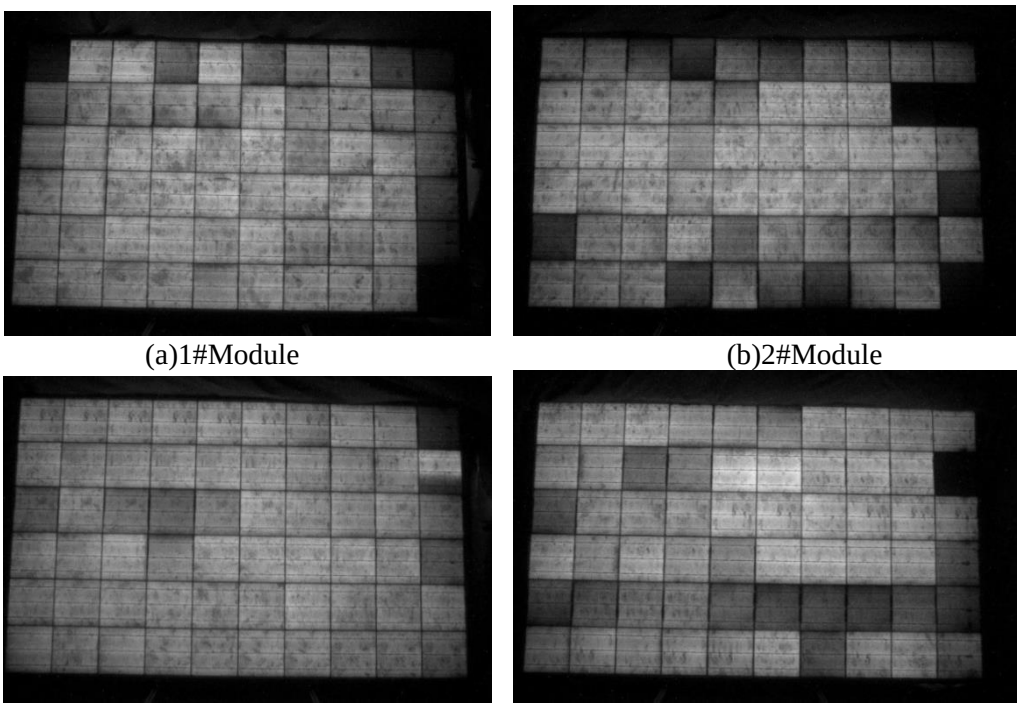
In this study, the typical PV modules samples were selected to analyze from a large number of PV power plants in many typical climate regions in China. The electrical performance and electroluminescence (EL) testing of PV modules taken from the power station were carried out. The electrical performance test is based on the method and procedure of the MQT 02 maximum power test

in the IEC61215 Terrestrial photovoltaic (PV) modules - Design qualification and type approval series. The test conditions were standard test conditions (AM1.5, 1000W / m^2, 25 ℃) using the indoor pulsed solar simulator method.

Laboratory simulation PID test referred to IEC TS 62804-1 Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon standard method. The samples were subjected to electrical performance and electroluminescent (EL) test after PID simulation.

3. Results and Discussion

It is found that the probability of occurrence of PID in PV systems in different climatic regions is significantly different. For the same type of PV systems, the most frequent occurrence of PID phenomena is in high temperature and high humidity areas. Some modules from a rooftop system site in high temperature and high humidity area were tested. The EL images are shown in Figure 1, it can be found that obvious black cell phenomenon is near the border of the cells, which is the typical PID effect. From the maximum power data under STC as shown in table 1, these four modules have different degrees of power degradation, and the averaged degradation rate is more than 15.97%.



(a)1#Module (b)2#Module

(c)3#Module (d)4#Module

Fig.1 EL images of PV modules in high temperature and humidity area

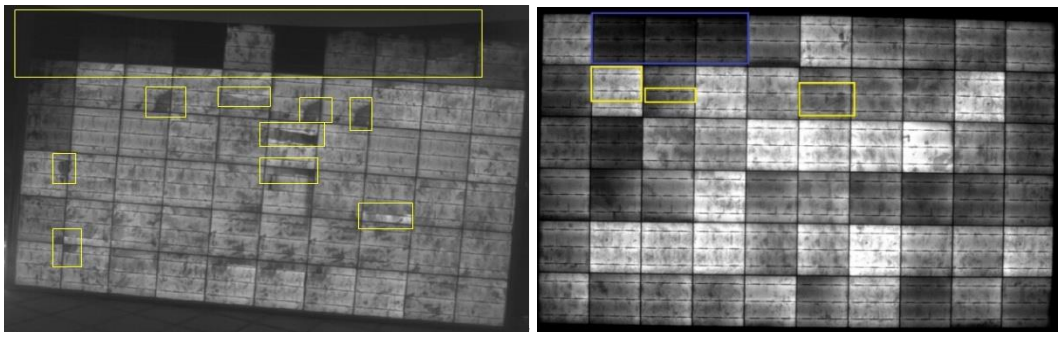
Table 1 Power under STC of PV modues from high temperature and humidity areas

Module No.	Rated Power [W]	P_{max}, STC [W]	Power Degradation [%]
1#	240	197.53	-17.70
2#	240	190.65	-20.56
3#	240	217.14	-9.53
4#	240	201.35	-16.10

The temperature and humidity results from the in-site test show that maximum atmosphere temperature at noon of August is about 38℃, and roof temperature of the building is usually higher than the atmosphere temperature, so the working temperature of modules in this environment is likely to reach 70℃ -80℃. At the same time, this region is relatively humid in summer, relative humidity can usually reach above 70%RH, especially in the afternoon after the rain, the relative humidity of the environment is getting higher in such environmental condition. For installation of PV system on this roof, typical PID phenomena will be more likely happened to modules.

For a rooftop PV system in temperate semi-humid climate area, part of the modules also appear PID phenomena, the EL images shown in Figure 2 are typical PID phenomena, but The degree of PID phenomenon of relative to the high temperature and humidity area is significantly weakened.

It is also observed that the probability of occurrence of PID phenomena in PV system in low-temperature and arid areas is much smaller. From the above-mentioned results, it can be seen that the temperature and humidity are important factors for the occurrence of PID, and it is more likely to achieve PID phenomena in high temperature and humidity areas.



(a) (b)

Fig.2 EL images of the PV modules in temperate semi-humid area

Meanwhile, in some high temperature and high humidity coastal area, more serious PID phenomenon,as shown in Figure 3(a), was found on modules relative to the high temperature and humidity areas.from the EL image cells in module are almost all black, only 7 active cells can be seen. The maximum power at STC is only 25.2W, declined 89.7% compared to the rated power. This indicates that besides to the impact of temperature and humidity, there may be other factors. By comparing the conditions of high temperature and high humidity areas, the main difference is the content of salt spray in the air of the coastal areas. With the increase of salt spray in the air, the PV module surface is more likely to gather conductive materials, which results in more leakage current in PV modules and promotes the occurrence of PID phenomena.

The PID recovery test was carried out under the conditions as following: the ambient temperature was 85 ℃±2 ℃, the relative humidity was 85%±5% , the bias voltage was +1000V, and the test time period was 96h. The EL image is shown in Figure 3(b). It can be seen that more cells become bright in

the module after the PID recovery experiment although many cells were still black.The maximum power at STC has also been a certain recovery from 25.2W to 62.2W, the decay rate increases from 89.7% to 74.6%. This shows that PID phenomena can be recovered to a certain degree after positive-bias voltage duration.

(a) (b)

Fig.3 EL images of modules from the PV system.(a)before positive bias PID test,(b) after positive bias PID test

In order to study the possible effects of other factors, some modules of rooftop PV systems have also been studied in the central non-coastal area. There are obvious PID phenomena in this system. The EL image in Figure 4 shows that the module has a significant PID Phenomenon. The maximum power of the module is 132W, declined 32.3% compared to the rated power.

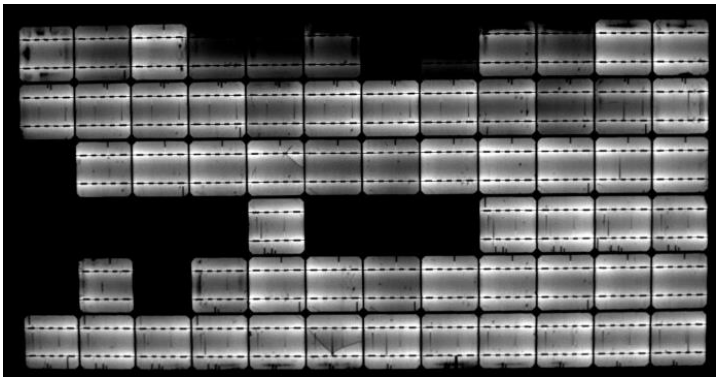


Fig.4 EL image of module from PV system

The PID phenomena of modules in this climatic conditions are not common.Further study found that the location of this PV system is surrounded by industrial manufacturing plants, and the surface of modules was covered with a layer of metal material that can not be removed,which may cause an increase of leakage current path on modules, resulting in increasing the possibility of PID phenomena.

4. Conclusions

From the analysis of PID phenomena in PV modules under typical climatic conditions, it can be seen that the PID phenomena may occur in PV plants under different climatic conditions, but their influence on the power degradation is different. The typical PID phenomena occur near the border of cells in PV

modules. The temperature and humidity are the main influencing factors, and the presence of salt mist and metal conductive material in the air will also promote the occurrence of PID phenomenon, the occurrence of PID modules can be a certain degree of power recovery after positive-bias voltage duration.

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