A Basic Study on Anti-reflection Coating PV Technology for Reducing Reflected Sunlight on the Building Skin

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Abstract

A rapid increase in population numbers due to recent advanced industrialization and social developments has led to the emergence of mega cities. The concentrated form of multiplexes and large-scale landmark buildings have resulted from improvements in high-rise residential facilities for accommodating urban residents as well as because of cultural factors. Urban-scale related problems such as traffic, noise and vibration occur accordingly, and in particular there is a growing number of sunshine, prospect, glare effect and light pollution-related problems. In this regard, restrictions and regulations are specified throughout the world in order to secure the prospect for indoor occupants against light pollution. Therefore, the purpose of this study is to seek ways to tackle the problem of glaring inside and outside the building and save energy in order to improve the light environment for indoor occupants. For such purposes, the building integrated photovoltaics system (BIPV) that can reduce the reflected light was used, and the basic data for reducing reflected light and creating solar photovoltaic energy were derived from previous application cases. In this study, the BIPV skin design was proposed in order to reduce the reflectance of reflected sunlight and improve the indoor light environment. The louver-type BIPV with module is the module that can reduce direct reflectivity and produce power through anti-reflection coating, and it is judged that this will be highly effective for dealing with light pollution-related circumstances.

Keyword: Solar Photovoltaic System, Sunlight Reduction, BIPV, Building Energy, Double Skin

1. Introduction

The growth of mega cities is occurring in modern societies due to advanced industrialization, and the increase in large high-rise residential facilities and office buildings is also taking place as a result of cultural developments and improvements in living standards. The range of effects

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on surrounding environments that includes previous environmental concerns such as traffic, noise and vibration in addition to issues related to sunshine, prospect, glaring effect, energy load and mental health issues at the time of construction of a new large building are being analyzed newly. Especially, there is a constantly growing social interest in pleasant light environments, and there is also a growing interest in light pollution.

In this regard, high-reflectance glossy materials are used on most building envelopes for high-rise buildings in downtown areas to obtain landmark status and the prospect of indoor occupants, causing visually excessive reflected light. This becomes the cause of light pollution that leads to glaring problems for drivers on surrounding roads and indoor occupants in surrounding buildings, so practical use and regulation measures are necessary. Therefore, the Seoul Metropolitan Government recommends the use of building skins with a reflectance of between 12% and 18% for buildings where reflective glass is used in the architectural review process to secure a pleasant light environment through the Act on the Prevention of Light Pollution due to Artificial Lighting based on 100% mirror reflectance and, accordingly, the development of skins related to the problem of reflectance is also increasing[1].

Especially, the PV cell among the components of the BIPV that is the skin system can be utilized as an element with multiple functions for reducing reflectance and saving energy through technical developments by means of anti-reflection coating, and it aims to be an efficient complex skin for power generation and the improvement of the indoor light environment. Therefore, the purpose of this study is to carry out a basic study regarding the BIPV skin design for reducing the reflectance of reflected sunlight and improving indoor light environments.

2. BIPV System for Reducing Reflected Light

2.1 Concept and Characteristics of BIPV System

The BIPV is the system that establishes the envelop integrated with the building including the PV system, and it has advantages such as reducing the building load and generating the power. For the BIPV (building integrated photovoltaic) system, there are various building elements that can be integrated with the building including the curtain wall, skylight, awning and clear PV windows and doors as shown in [Table 1]. Such components can be used for natural lighting or awnings according to the characteristics, but it is important to apply such

components to the BIPV system at a proper angle and location according to each installation environment[2].

[Table 1] BIPV Application

Building name	Picture showing its application	Summary
Printing Industry Support Center (Daegu)		-Installation method: Wall type -Installation year: 2014
Seoul City Hall (Seoul)		-Installation method: Roof type -Installation year: 2011
National Institute of Environmental Research (Incheon)		-Installation method: Atrium type -Installation year: 2010
Green City Experience and Training Center (Gangneung)		-Installation method: Balcony type -Installation year: 2014

2.2 Concept and Specification of PV

PV is the smallest module that converts light energy into electrical energy directly as shown in [Fig. 1] The PV is the PV panel that generally has the pn junction structure and its electrical energy generation principle is as shown below. When a photon from the outside is absorbed into the PV, an electron and a hole will be generated inside the PV module due to energy carried by the photon, and the generated electron and hole will move to the n-type semiconductor and p-type semiconductor respectively by the electric field generated in the pn junction, operating the load and generating energy[3]. The specification of the PV used as the standard in this study is a 156 mm×156 mm sized module based on the manufacturing specifications of the PV manufacturer[4].

[Fig. 1] Concept Map of PV System

2.3 Concept and Characteristics of PV Anti-reflection Coating

The PV (Solar Photovoltaic Cell) anti-reflection coating reduces the reflection on the surface between two entities that have a different sunlight refractive index as much as possible and absorbs sunlight[5]. Generally, the silicon nitride (SiN_x) film is used in Korea as the reflectance reduction element and the surface reflection on the reflector is reduced to increase the intensity of transmitted light and eliminate scattering light due to reflection. As shown in [Fig. 2], when the sunlight passes through the surface between two entities with a different refractive index, a part of the reflected wave reflects off on the surface and moves in the reverse direction. The idea is that the light reflected at the top layer and the light reflected at the bottom layer create destructive interference with each other, reducing the reflectance[6].

[Fig. 2] PV Reflection Barrier Description

2.4 Trend of Anti-reflection Coating Technologies at Home and Abroad

(1) Clear cell technology

The solar photovoltaic produced using the spray method has a cost advantage in comparison to the previous solar photovoltaic cell produced using an expensive silicon wafer. In addition, it can be produced faster in comparison to the thin film solar photovoltaic cell that requires a high degree of vacuum pressure and high temperature heat treatment, and the solar photovoltaic cell can produce electricity using direct sunlight irradiation as well as a fluorescent light.

(2) Plasmonic thin film solar cells

The concept behind a thin film solar photovoltaic cell is to apply silver (Ag) nano particles to the surface. In such case, the incident light does not reflect but refracts, bounding back to the front or rear in the solar photovoltaic cell. This uses the plasmonic phenomenon of metallic nano structure, and light with long wavelength can be absorbed. The photoelectric transformation efficiency of the CdTe thin film solar photovoltaic cell using the plasmonic phenomenon is improved by 30% in comparison to the previous solar photovoltaic cell.

(3) Single layer anti-reflection coating

For the single layer anti-reflection coating, the single layer anti-reflection coating made of silicon nitride (SiN_x) was used instead of double anti-reflection coating. The previous PERL cell involves a complicated optical lithography process using a mask for texturing in an inverted pyramid shape, so the production cost is high, but the previous PLUTO cell produces the pyramid shape using the texturing process, and the flat surface between the created pyramid shapes is removed to reduce the reflectance of light. It acts to reduce the loss incurred by the increased reflectance caused by single layer anti-reflection coating.

(4) Deep reactive ion etching

In the previous solar photovoltaic cell production process, the silicon nitride (SiN_x) film was produced in a single layer to form the anti-reflection coating, but a double anti-reflection coating was formed instead of the silicon nitride (SiN_x) film to reduce the reflectance of sunlight on the surface of the solar photovoltaic cell. Moreover, the nanotip was created on the surface of substrate using the deep reactive ion etching technology instead of the previous wet chemical texturing, reducing the surface reflectance of the solar photovoltaic cell, in order to

improve the surface texture of the solar photovoltaic cell.

[Table 2] Trends Related to Anti-reflection Coating Technologies at Home and Abroad

Company name	Picture of product	Anti-reflection technology
New Energy Technologies		Clear cell technology
Australian National University		Plasmonic thin film solar cells
SunTech		Single Layer Anti-reflection coating
SHINSUNG E&G Co., Ltd.		Deep Reactive Ion Etching

3. Proposal of the Double Skin using the Anti-reflection BIPV System

The purpose of this study is to propose a building skin design that promotes improvements in the light environment by reducing light pollution and reducing building energy requirements by implementing the skin module of the BIPV system for reducing reflected sunlight as shown in [Fig. 3].

The louver-type BIPV where the anti-reflection coating PV module is inserted is attached at the top part for reducing reflected sunlight, and it aims to reduce elements that can affect the reflection directly by extending the length of the BIPV in the curtain wall in order to shade direct solar radiation partially[7]. It is judged that the BIPV module for reducing sunlight in this study can improve the light environment and facilitate the production of building energy, and the intelligent module that could meet each proper angle was suggested[8].

[Fig. 3] Skin Module of BIPV System for Reducing Reflected Sunlight

4. Conclusion

In this study, the BIPV skin design was proposed in order to reduce the reflectance of reflected sunlight and improve the indoor light environment. The louver-type BIPV with module is the module that can reduce direct reflectivity and produce power through anti-reflection coating, and it is judged that this will be highly effective in dealing with light pollution-related circumstances.

Therefore, this study has significance in that it focuses on reducing sunlight reflectance. Since the numerical values regarding the brightness and glaring of reflected light created from a building are not considered in this study, further studies are required in the future that address this matter.

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