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Performance evaluation of vacuum photovoltaic insulated glass unit

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Abstract

Although semi-transparent photovoltaic windows can generate electricity in situ, they also increase the cooling load of buildings significantly due to the waste heat as a byproduct. However, vacuum glazing, which has excellent thermal insulation, can effectively solve the above issues for PV windows. In order to take advantage of excellent thermal insulation performance of vacuum glazing, a novel vacuum photovoltaic insulated glass unit (VPV IGU) was presented. The electrical characteristics of the PV laminated glass were tested in laboratory under standard test conditions. Then power generation and thermal performances of the VPV IGU were evaluated through experiments. Results have indicated that the VPV IGU can not only generate electricity, but also help reduce the cooling load as well as improve the indoor thermal comfort.

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1. Introduction

Building-integrated photovoltaic (BIPV) system is already an option for today's building elements with numerous successful examples due to its novel integral function of power generation from solar energy resource and decoration, simultaneously serving as building envelope material [1]. In modern high rise structures, semi-transparent photovoltaic (STPV) panels, or PV windows, which admit a specific amount of daylight into an indoor space, have been widely used as portions of the façade [2]. However, despite the fact that PV windows absorb majority of incident solar irradiation, only a small part of

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absorbed energy will be converted into electricity, with the remaining energy converted into heat [3]. The waste heat not only reduce the energy conversion efficiency of PV windows but also increase the heat gain of indoors. In addition, the structure of conventional single pane PV glazing also result in higher U value [4, 5].

The vacuum glazing, initially proposed by Zoller in 1913, could minimize conductive and convective heat transfer to a negligible value via a vacuum gap [6]. The best U-value of the vacuum glazing was reported to be $0.86 \text{ W/m}^2\cdot\text{K}$, much lower than that of air/argon filled double glazed windows [7]. Therefore, in this study a novel vacuum PV insulated glass unit (VPV IGU) which combined vacuum and PV glazing technologies was developed. The VPV IGU is expected to not only generate electricity in situ, but also improved the thermal insulation performance of conventional PV glazing.

So far, few studies have investigated the energy performance of VPV IGU. The objectives of this paper are to introduce a novel vacuum PV insulated glass unit (VPV IGU) and evaluate its power and thermal performances through experiments. The results are expected to provide a reference for the development of PV glazing applications.

2. Structure of VPV IGU

The novel VPV IGU was made by sandwiching a layer of polyvinyl butyral (PVB) between an external PV laminated glass with 20% transmittance and an internal vacuum glass with Low-E coating deposited on the third surface (toward outside). The U-value of the vacuum glass is as low as $0.8 \text{ W/m}^2\cdot\text{K}$. The structure of the VPV IGU is shown in Fig. 1. The dimension of the VPV IGU is 1300 mm (width) \times 1100 mm (height) \times 20.87 mm (thickness), thinner than commonly used PV double glazed insulating glass units [4].

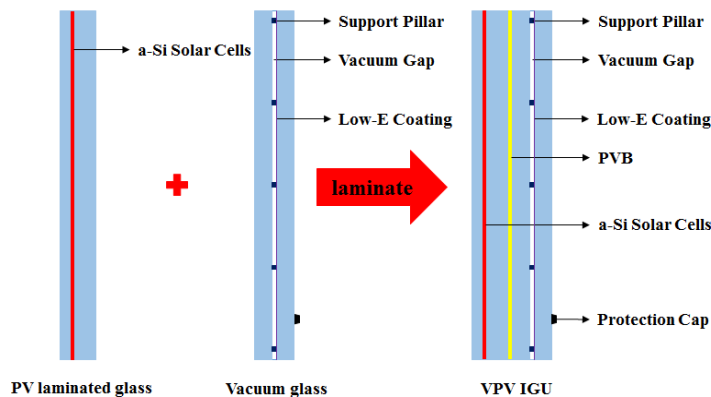


Fig. 1. Structure of VPV IGU

3. Experiment set-up

Before the outdoor testing, the electrical characteristics of the PV laminated glass were tested in laboratory under standard test conditions (STC, viz. air mass 1.5, solar irradiation 1000 W/m^2 and cell temperature $25 \text{ }^\circ\text{C}$) using a triple A class solar simulator and results are listed in Table 1.

In order to evaluate the energy performance of the VPV IGU, an outdoor testing was conducted on the platform of Block Z in The Hong Kong Polytechnic University from June 2016. The VPV IGU was set

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