Film Type Amorphous Silicon Photovoltaic Module and its Application Technology

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ABSTRACT

Fuji Electric's photovoltaic modules are formed by encapsulating solar cells fabricated on a plastic substrate without using glass. These modules are lightweight, flexible, thin and unbreakable, and can be installed on a building without requiring that the building structure be reinforced. Laminating these modules to various materials such as a curved steel plate enables the modules to be integrally formed with advanced building materials such as roofing materials or wall materials. Also, integrating with non-building materials, such as a waterproof sheet, and improving the installation method will expand the range of possible installation sites and usage methods as well as increase the added value. The cells are formed with a series-connection structure that enables modularization of the cells with only simple wiring and facilitates the fabrication of larger cells areas.

1. Introduction

The production of photovoltaic power has increased rapidly over the past 10 years, with product output growing at a rate of 30 to 40% annually, and is driving force behind the environmental and energy policies of countries throughout the world. A backdrop to this rapid growth is the global challenge of reducing greenhouse gas emissions. As one response to this challenge, Fuji Electric is working to manufacture, sell and promote the widespread usage of solar cells.

There are various types of solar cells, and these different types are made from different materials. Fuji Electric has been researching and developing amorphous silicon solar cells since 1978. Amorphous silicon solar cells have a large optical absorption coefficient in the visible light range, and can be fabricated as a thin film having a thickness as small as 1 mm. The nominal output of a solar cell is defined as the output value at the reference temperature of 25 °C. Actual operating temperatures for outdoor use are often higher than 25 °C. Because amorphous silicon has a larger energy band gap than liquid crystal silicon and resists degradation of its power output even at high temperatures, amorphous silicon solar cells are said to be highly practical. Since October 2004, amorphous silicon fabricated on a flexible plastic film substrate and encapsulated by a polymer has been sold as lightweight, flexible and unbreakable film modules.

2. Photovoltaic Modules

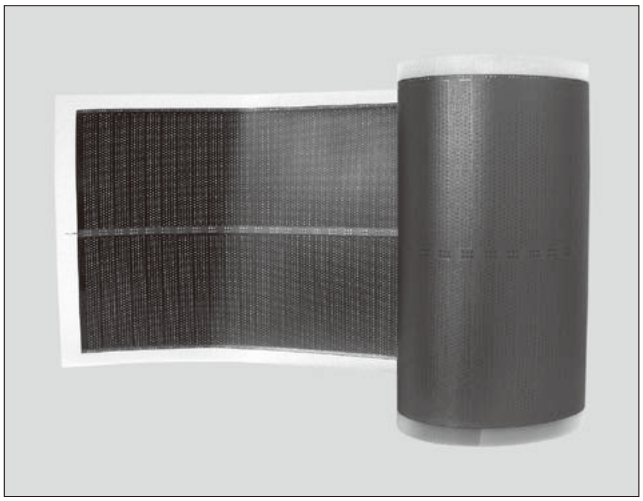
Fuji Electric's photovoltaic modules shown in Fig. 1 have the following characteristics. The modules are categorized roughly into BIPV (building-integrated photovoltaic module) and BAPV (building-applied photovoltaic module) types.

(a) An integrated series-connected structure has been incorporated at the production stage. Consequently, large dimensions can be realized easily with modularization and simple wiring, making it possible to cover an entire roof or side wall.

(b) By eliminating the glass on the light receiving side, the securing frame and so on, and by covering that surface with a weather-resistant polymer, lightweight, flexible and unbreakable modules that did not exist previously can be fabricated.

(c) In addition to the conventional stationary-type modules, photovoltaic modules that are glued together with various materials and integrally formed with building materials, such as roofing materials or wall materials, and that achieve

Fig.1 Flexible photovoltaic module



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harmony with their surroundings, can be realized.

2.1 BIPV

The BIPV modules sold so far have mainly been the glass covered type. Glass-covered modules have a heavy weight per unit area. Accordingly, their use requires roof reinforcement and their size has been limited. Targeting application to the roofs of buildings, especially large public or industrial buildings, Fuji Electric has been supplying lightweight BIPV modules made from a film-type photovoltaic module laminated directly to a steel plate. These BIPV modules can be applied in the same way as an ordinary steel roof, enabling the realization of a steel roof equipped with low-cost and well-designed solar cell functionality. In addition, because they are flexible, the steel plates can be bent and installed on curved surfaces as shown in Fig. 2, resulting in excellent design characteristics when installed on a dome-shaped roof or at locations where a refined design sense is desired. Also, in the field of construction waterproofing, a technique that uses waterproof sheets has been used increasingly due to its short construction period and low cost, and even higher added value can be obtained by integrating these waterproof sheets with sheet-like solar cells (Fig. 3).

Fig.2 Minato Mirai in Yokohama, Japan

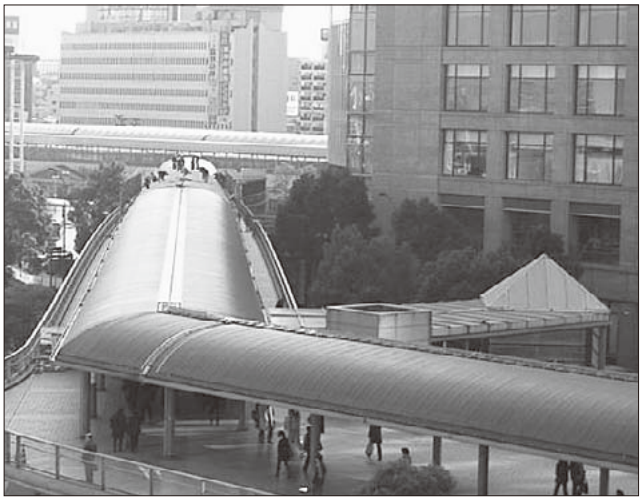
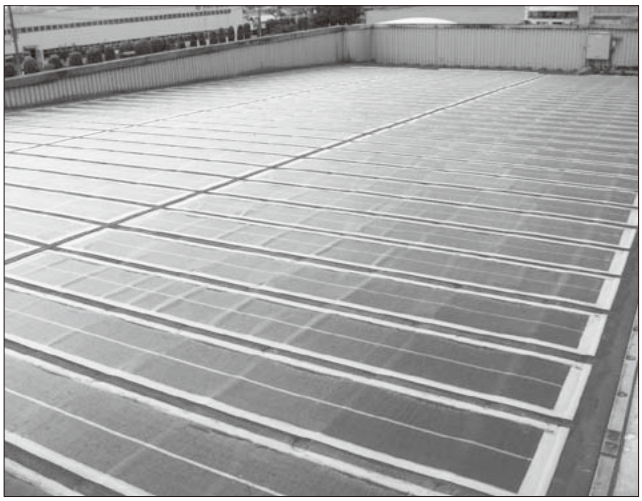


Fig.3 Waterproof sheet type



2.2 BAPV

BAPV modules are typically encapsulated by a fluorinated polymer having excellent weather resistance specifications. These photovoltaic modules exhibit excellent durability without sacrificing flexibility. Installation methods and methods for attaching mounting pins have been proposed according to the needs of the user. The potential for various other uses also exists, and applications in a wide variety of fields, such as to vending machines, covers for water treatment plants, energy-saving devices (such as household electric appliances), soundproof walls along a highway, and waterproof sheets, are being considered (Fig. 4).

Steel plate folding-type modules are also being sold for use on existing roofs.

When installing a solar cell on an existing building, the weight of the solar cell installation must not exceed the load capacity of the building. In the case of

Fig.4 Solar raft type

Fig.5 Solar cell on roof of bicycle parking lot, Kumamoto prefectural government

a building having a small load capacity, reinforcement is necessary. Fuji Electric's steel plate folding-type modules have a weight, including the steel plate itself, of approximately 4 to 8 kg/m^2 which is about half that of stationary type modules made by other companies, and therefore reinforcement of the building is not required (Fig. 5).

3. Module Installation Techniques

Solar cells are typically installed on the roof of a building or on a custom frame pedestal. Due to space constraints, however, these cells have only achieved a limited increase in popularity. As a solution, modules that are easier to install are being developed and installation demonstration tests are being conducted. Because film-type modules are fabricated exclusively from polymers, they are not suited for installations where the modules are only partially attached, and instead have had to be attached to the surface of structural objects such as steel plates. However, by embedding metal in a module and providing anchoring holes formed in this metal, the module can easily be attached a structural object. Moreover, the module has a weight of approximately 2 kg/m^2, which is extremely light.

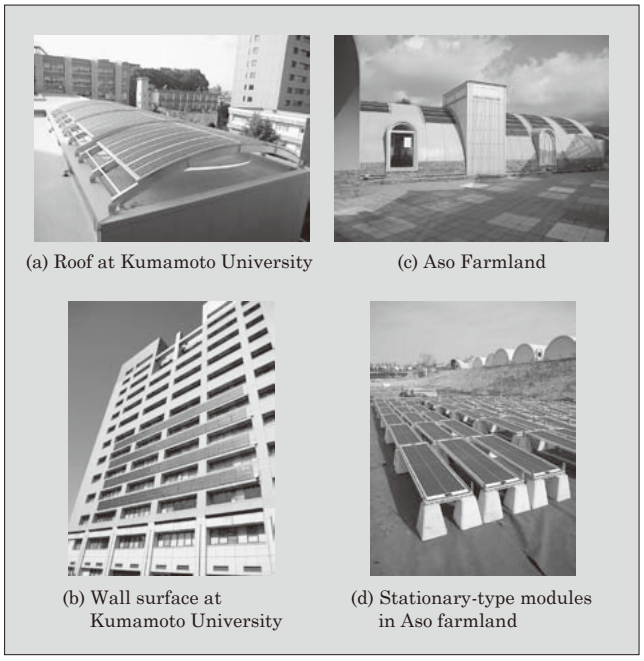
Fig.6 Entrance to Fuji Electric's Tokyo Plant

Figure 6 shows an example installation at the entrance to Fuji Electric's Tokyo plant. The modules are lightweight and thin and can be integrated with the walls, resulting in a natural appearance that is in harmony with the surroundings.

Following the experimental installation at the Tokyo plant, as a Japanese national project, the installation is being validated in collaboration with the Kumamoto Technology and Industry Foundation and Kumamoto University (Fig. 7).

Temporary and easy installations, whereby land for which there is no planned usage, such as unused farmland and other idle land, is utilized effectively by installing modules secured with wire or rocks so that they may be moved if the land subsequently is allocated to other applications, are also under consideration, and these installations are being validated.

Fig.7 Photovoltaic modules undergoing validation testing



Film-type modules fabricated exclusively with polymers are products that target mostly overseas applications with system integrators. Using a fluorinated polymer having excellent weather resistance as their surface material, these modules exhibit superior long-term reliability. Fuji Electric has accumulated expertise in adhesives, and this knowledge is included in the installation manual provided to customers so that the photovoltaic modules can be affixed securely to the desired adherend.

4. Postscript

This paper has introduced film-type amorphous photovoltaic modules and their application techniques. Through leveraging the advantages of lightweight, flexible and unbreakable film-type amorphous solar cells, Fuji Electric is determined to develop products that meet customer needs, to promote the usage of solar cells further through proposing various installation techniques, and to contribute to efforts to prevent global warming.