# New Concept of Thinner CPV Module with High Performance at Low Cost

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Concentrator photovoltaic (CPV) modules which consist of concentrator optics and high-efficiency multi-junction solar cells are suitable devices for generating high electrical power per unit area. Marc Steiner et al. achieved 43.4 % by the mini-module CPV [1]. On the other hand, the conventional CPV systems need a sophisticated assembly process for placing the solar cells in the focal area of the optics, and they use large heat sinks to disperse heat from the solar cells. These features make the CPV modules large, heavy, and complicated structures, then resulting in increased process and deployment costs for the systems.

Panasonic has been developing a compact and thin CPV module with a 20-mm thickness using a self-alignment method for placing solar cells with an area smaller than 1 $mm^2$ to decrease the weight of the module and to simplify the module's assembly process, aiming to decrease the process and deployment costs of the CPV system [2]. Based on the technology developed for our previous CPV modules, we propose a CPV module with a new concept, the Plastic lens Integrated III-V compound semiconductor Cell module (PIC), to achieve high energy conversion efficiency at low cost.

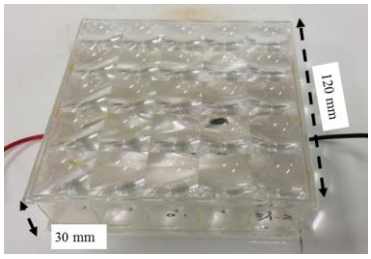
The main components of PIC are a primary optical and a secondary optical element (POE/SOE), a circuit board with solar cells. The Optics and circuit board are made from plastics of poly methyl methacrylate (PMMA), which is lightweight and cheap. The PMMA optics are fabricated with an accuracy of a few micrometers using an injection molding method. The SOE has a box-shaped structure with a sufficient area upon which to place the POE. The optical axis of the POE and SOE can be easily aligned by simply fitting the POE to the SOE mechanically, since each optic are fabricated with an accuracy of a few micrometers. Consequently, the optical system of PIC can be assembled using a simple low-cost process. Solar cells with a size smaller than 1 $mm^2$ downsize the module thickness. Since the heat in solar cells disperses off them efficiently with a decrease in cell size, PIC can adopt a smaller heat sink than that of conventional CPV, achieving a compact structure. The circuit board is fabricated at low cost using a screen-printing and surface-mounting technology (SMT) because these technologies are already widely used for mass-producing electronic devices at low cost. The structure and assembly process of PIC described above enable the CPV module to be fabricated and deployed at low cost, achieving a system cost comparable to conventional flat panel photovoltaics (FPVs).

Figure 1 shows the picture of a preliminary PIC and I-V measurement results in outdoors at Kadoma City, Osaka, using a tracking system. The size of a primary optic array (5 × 5 lenses) and cell is 120 × 120 $mm^2$ and 1 $mm^2$. The thickness of this module is about 30 mm. We used glass substrates instead of PMMA substrates in this study. Nevertheless, we could demonstrate the concept of the structure and the assembly process of PIC using these glass substrates. The direct normal irradiance (DNI) and temperature were 900 $W/m^2$ and 30.1 °C. The energy conversion efficiency, open circuit voltage, short circuits current, and fill factor were 30.1 %, 15.7 V, 247 mA, and 0.80, respectively. The energy conversion efficiency of the bare solar cell on a wafer was 40 % under a simulator of 500 suns. We estimated that the lower efficiency of PIC compared to the bare solar cell is mainly due to the optical loss of the lenses. We plan to suppress this optical loss to increase the efficiency of PIC.

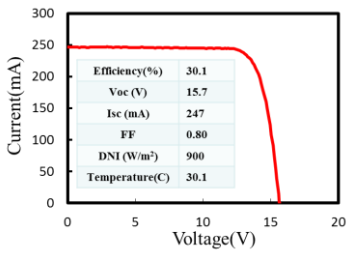
This study is based on the results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

**References**

[1] M. A. Green et al., Solar cell efficiency tables (version 47), Progress in Photovoltaics 24(1), 3-11 (2016)
[2] N. Hayashi et al., IEEE Journal of Photovoltaics, vol. 6, No. 1, pp. 350–357 (2016)




(a) Front-side picture




(b) I-V measurement (outdoors)

Figure 1. The picture of a preliminary PIC and I-V measurement results in outdoors