Area: 3 III-V Compound Semiconductor and Concentrator and Space PV Technologies

SOLAR POWERED CAR BY STATIC CONCENTRATOR PHOTOVOLTAICS

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This research investigated the benefits of utilizing solar power as an energy source for future vehicles. Due to strict emissions standards, alternative energy sources must be found for vehicles in the future. It was estimated that replacing all passenger vehicles with hybrid vehicles (HVs) equipped with an 800 W rated-power solar module that generates an average output of 1.8 kwh/day would reduce CO_2 emissions by 63% in Japan. To confirm the validity of this estimation, a test vehicle was created by installing a 6.8 m^2 solar module with c-Si cells onto a commercially available plug-in HV as shown in Fig.1. An average power generation of 2.1 kWh/day, equivalent to a drive range of 18.4 km from solar power, was obtained by this solar module over 100 days under real-world conditions (Fig.2), which was larger than the power required to achieve the estimated CO_2 emissions reduction.

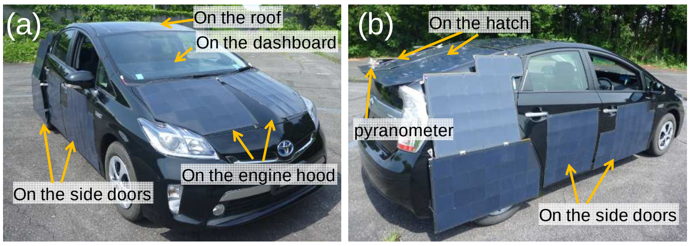

Fig.1 Photo of the test vehicle (Prius PHV).

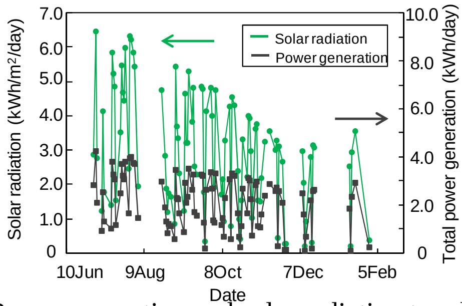

Fig.2 Power generation and solar radiation trends.

In addition, an innovative static low-concentrator with III-V cells was studied to help reduce the installation area of the solar module for practical vehicles. Since the module will be installed on an approximately horizontal plane (i.e. the roof and hood) and the direction of a vehicle is independent to the position of the sun, there is a large difference in the distribution of the sunlight incident angle between conventional terrestrial modules and an modules installed on a vehicle roof. The annual irradiation densities as a function of the incident angle of sunlight was calculated. The results suggest that a concentrator for a vehicle roof application must be designed to collect sunlight arriving from low incident angles (30-60°) highly efficiently without a tracker. To realize the new concentrator, a new design method was proposed that can be easily integrated into a standard vehicle design procedure by utilizing numerical optimization in a CAD-friendly environment. Both design equations and a design example are discussed in this paper. Our proposed lens design (Fig.3; asymmetric-aspheric type) can expand the acceptance incident angle of solar light and increase the annual energy yield of a solar panel (Fig.4), while maintaining the essential thin structure for automotive applications. In spite of wide range of the sun position, this asummetric-aspherical lens can keep stable illumination onto the cell while suppressing the maximum spot intensity to × 20.

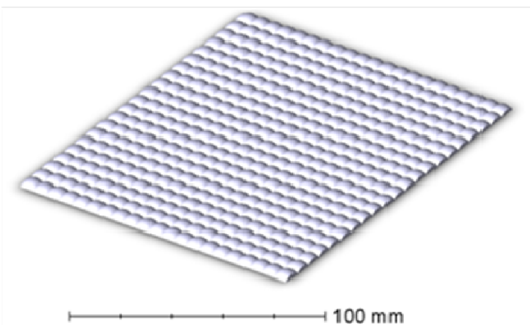

Fig.3 The designed lens sheet.

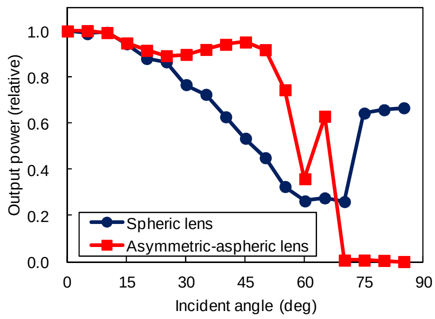

Fig.4 Characteristics of a designed concentrator.