22nd European Photovoltaic Solar Energy Conference and Exhibition, Fiera Milano, 3–7 September 2007, Milan, Italy.

TEST OF HIGH CONCENTRATION SOLAR CELLS FOR APPLICATIONS ON FLUXMETERS FOR SOLAR CONCENTRATO

A. Parretta*[1], G. Nenna[2], M. Pellegrino[2], C. Privato[2], L. Gentilin[3], A. Maccari[3], A. Mittiga[3], M. Montecchi[3], M. T

[1]ENEA Centro Ricerche "E. Clementel", Via Martiri di Monte Sole 4, 40129 Bologna (BO), Italy.
[2]ENEA Centro Ricerche Portici, I-80055 Portici (Na), Italy
[3]ENEA Centro Ricerche Casaccia, Via Anguillarese 301, 00123 S. Maria di Galeria (RM), Italy.

INTRODUCTION

Solar concentration cells of the type SunPower HECO252 were as photodetectors in fluxmeters for trough solar thermal concentrators. Two types of fluxmeters were investigated, both realized with a collar-shaped sensor head wrapping round the glass tube protecting the cylindrical thermal receiver. The first fluxmeter has a sensor head mounting a single cell directly exposed to the concentrated solar radiation and provided with an optical screen. The second fluxmeter was realized with a polygonal frame over which eleven cells, protected by diffusive windows, are distributed at regular intervals in order to cover the full angular range (~210°) involved with the concentrated light irradiation. The two fluxmeters were tested in a long campaign in the field, mounted on the PCS solar thermal concentrator of ENEA-Casaccia (Rome). No appreciable degradation was observed for the single HECO252 cell of the first fluxmeter within two months of direct exposition, whereas a long term stability was observed for the eleven HECO252 cells of the second fluxmeter.

HIGH FLUX DENSITY PHOTODETECTORS

We refer here exclusively to the SunPower HECO252 cell (see Fig. 1), a high efficiency concentration Silicon cell, realized with the advanced back contacts technology and suitable for high flux irradiation measurements of the order of two hundred suns.

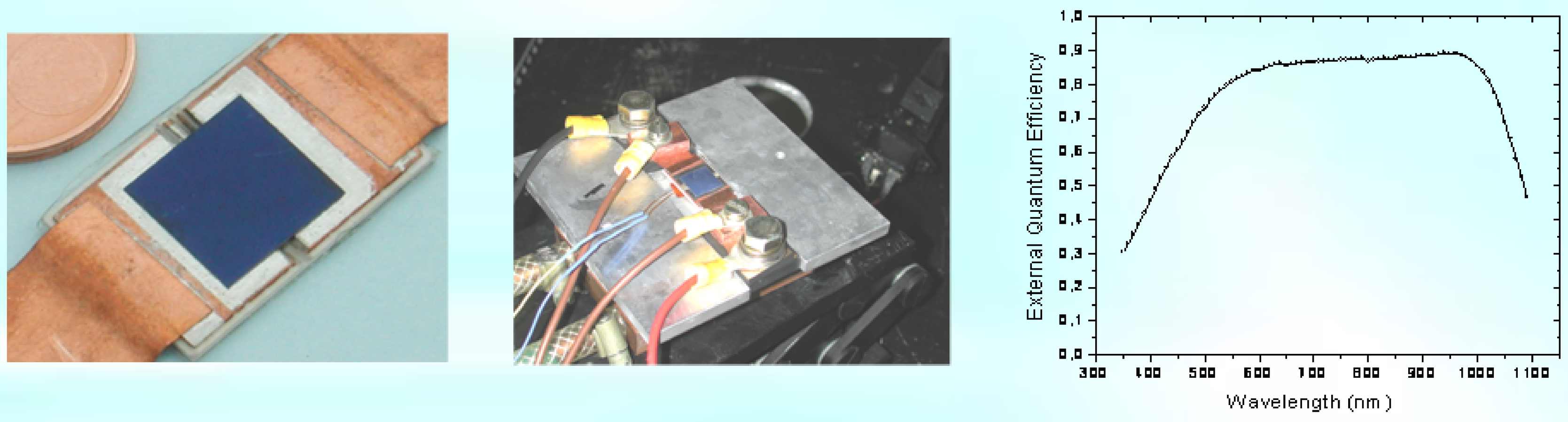


Figure 1. Solar concentration cell SunPower HECO252. (Left) Cell welded on a copper-coated AlN substrate. (Centre) Cell mounted on a support for tests at high concentration illumination. (Right) External quantum efficiency of the unexposed SunPower HECO252 cell.

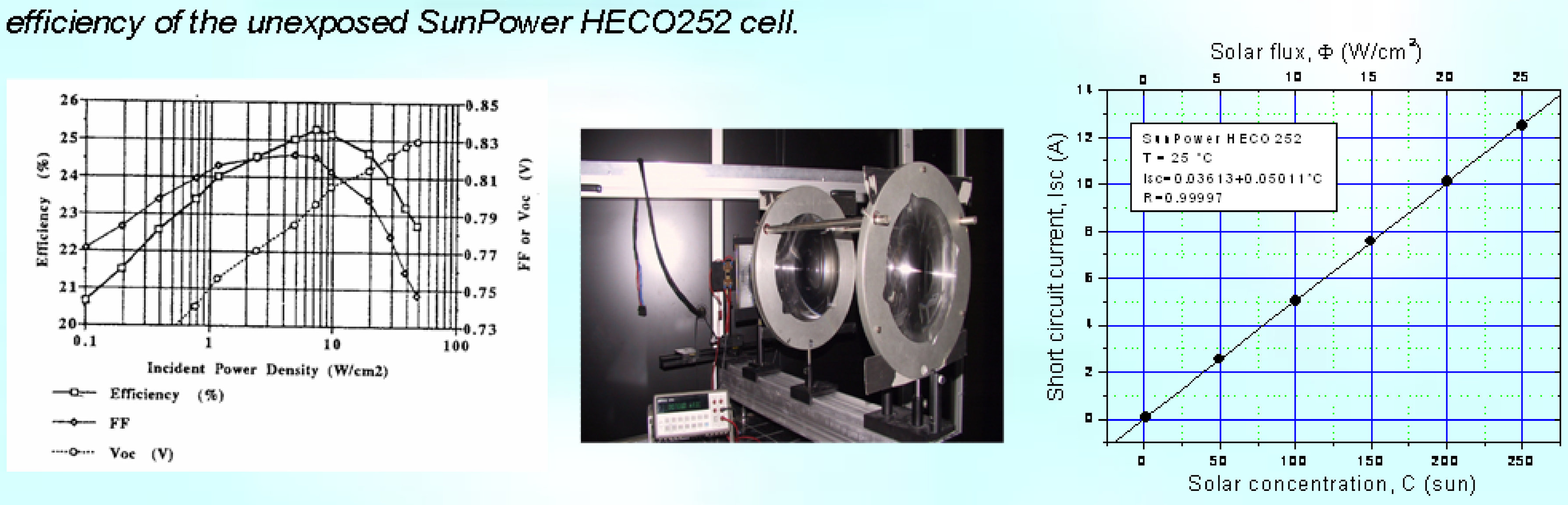


Figure 2. (Right) Typical efficiency, Voc and FF of the SunPower cell as function of the incident power density. (Centre) Particular of the indoor test measurements at concentrated light. (Right) Correlation between Isc of the HECO252 cell and flux density.

Before their use, the HECO252 cells were calibrated at the PASAN mod. 3B pulsed solar simulator, equipped with Fresnel lenses for concentration measurements (see Fig. 2). A linear correlation (R=0.99997) was found between short circuit current (in A) and simulated solar flux density at 25°C temperature (see Fig. 2b): Isc (A) = 0.036 + 0.501 · Φ (W / cm²).

THE FLUXMETERS

The first realized prototype of fluxmeter, FVC1 (Photo Voltaic Collar 1), is characterized head with a single solar cell (sc) as photodetector, directly exposed to the concen radiation (see figures below) [1]. The sensor has been realized by joining two anti cylinders for the assembling on the glass tube. The sensor operates with an optical st screen (os) with large view (aperture angle α) whose main function is to select the radiati on the receiver tube (rt); it improves, indirectly, the cooling of the cell.

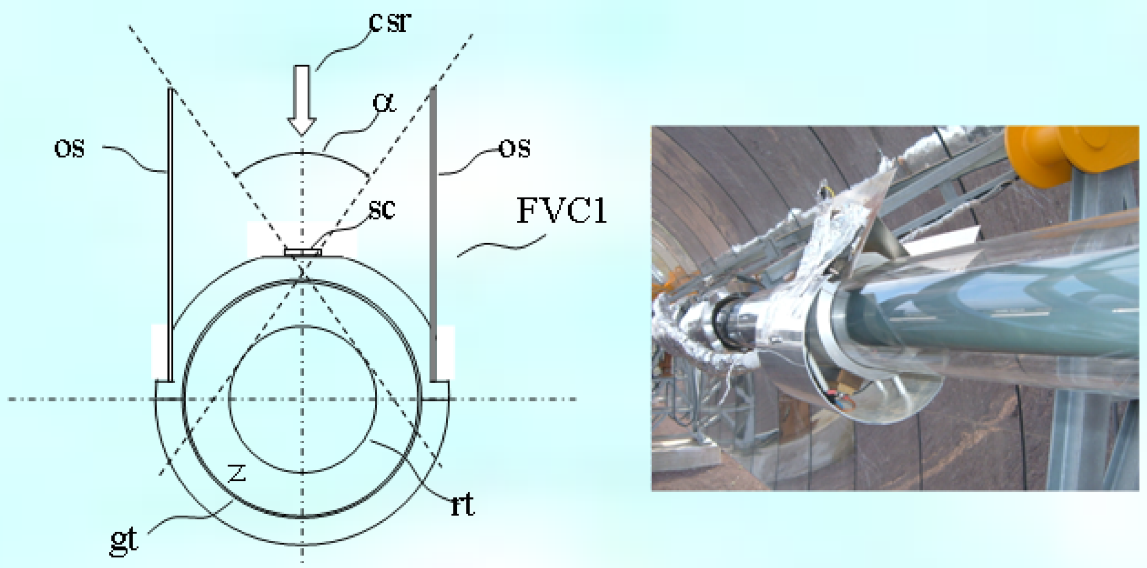
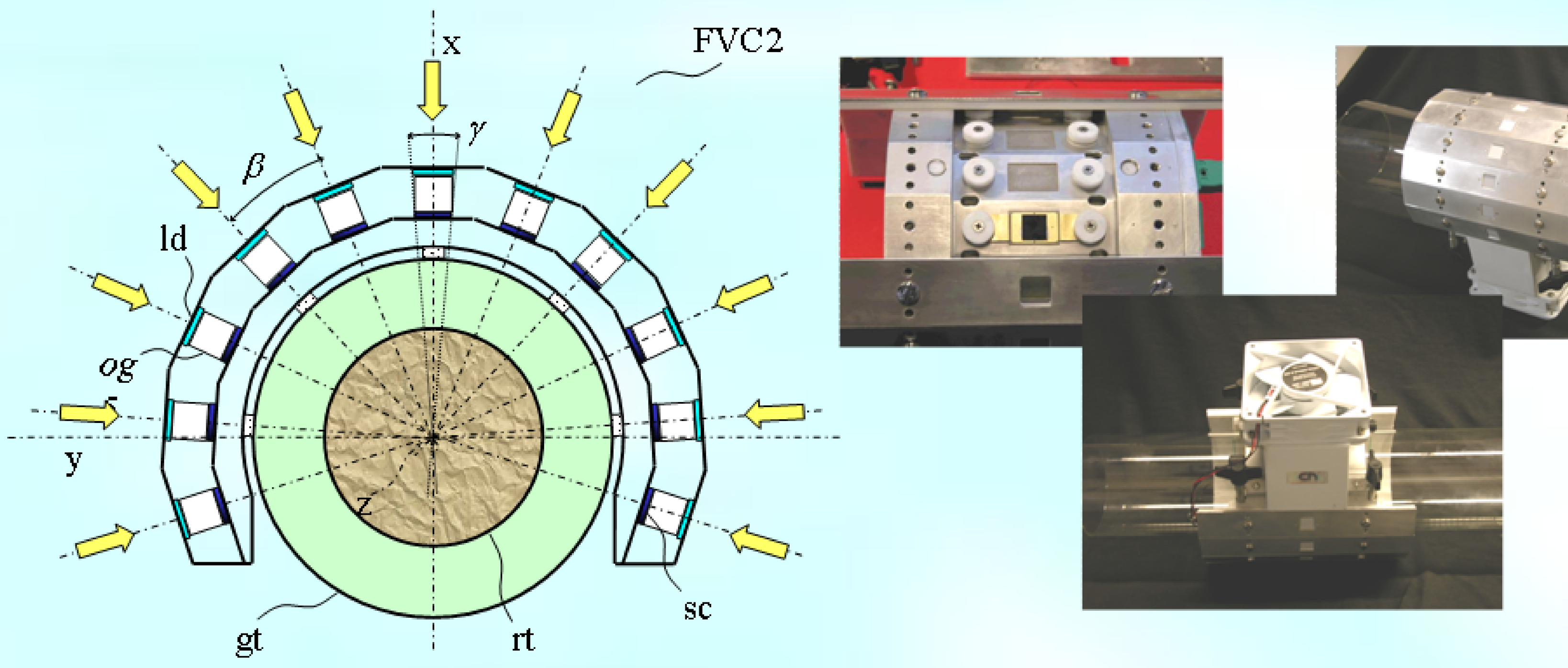


Figure 1. (Left) Schemat view of the FVC1 fluxmete Photos of the FVC1 moun PCS receiver.

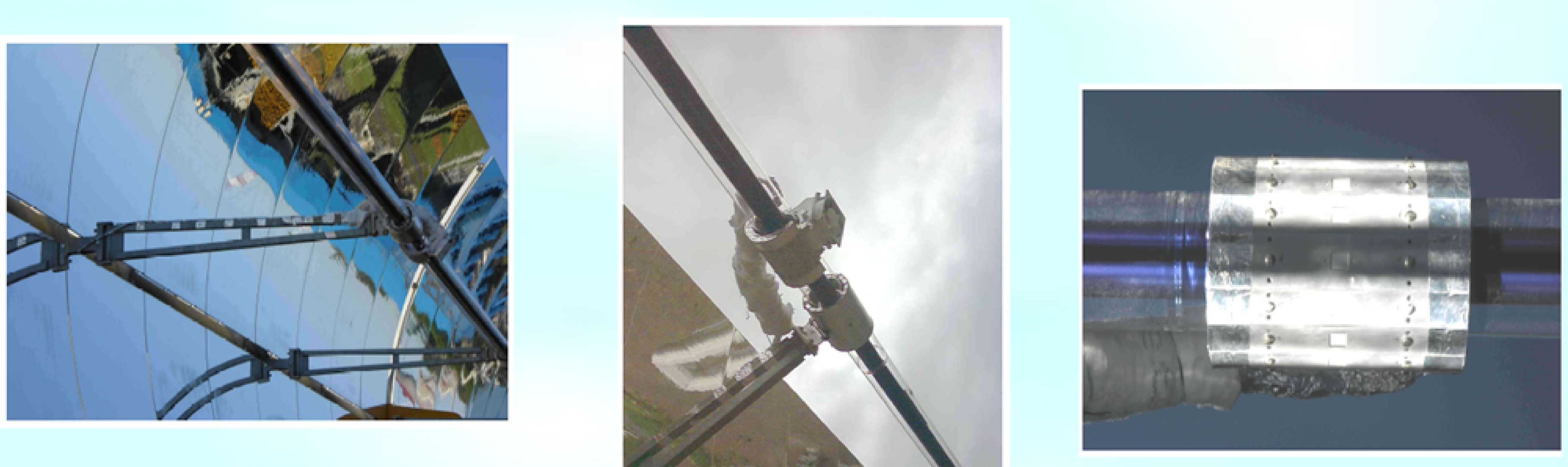
The sensor head is manually oriented towards the different directions (azimuth ang temperature is measured by a thermocouple welded directly under the cell substrate. with the CFV1 sensor produced 48.2 mA under 1000 W/cm² irradiation (AM1.5G). We m mV at AM1.5G on a shunt resistance of 0.015 W, and this value was used to convert the on the cell to irradiance values.



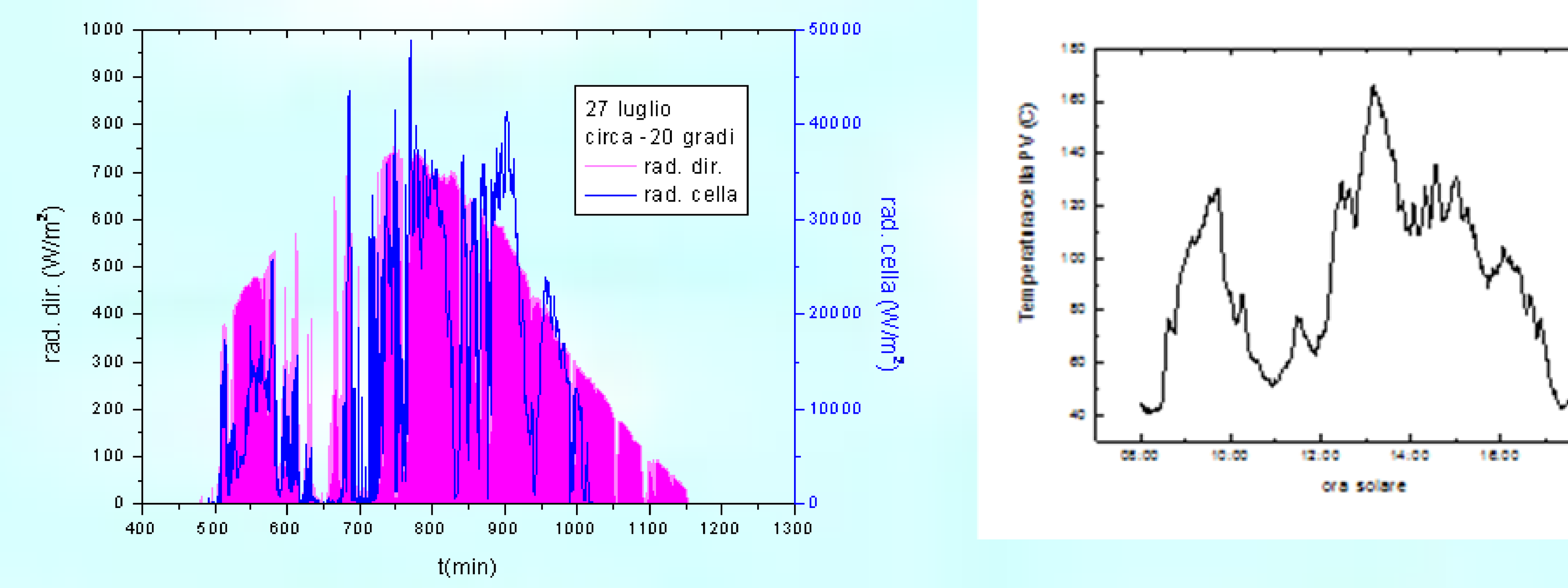
The second prototype, FVC2 (see the scheme and photos above), operates with eleve cells (sc) protected by as many translucent windows (ld) with quasi-Lambertian properties. The cells are distributed over ~210° angular interval. The concentrated light the diffusive windows (ld), is reflected by the optical guides (og) walls and is absorbed (sc). This arrangement allows to have a quite homogeneous radiation on the cells, indepe impinging direction on the windows (ld). To improve the dissipation of heat from the cells fan is used to extract air from the sensor body. Signals of photocurrent and temperature cells are brought to electrical connectors and measured by remote instrumentation.

TEST OF THE FLUXMETERS AT THE SOLAR PLANT

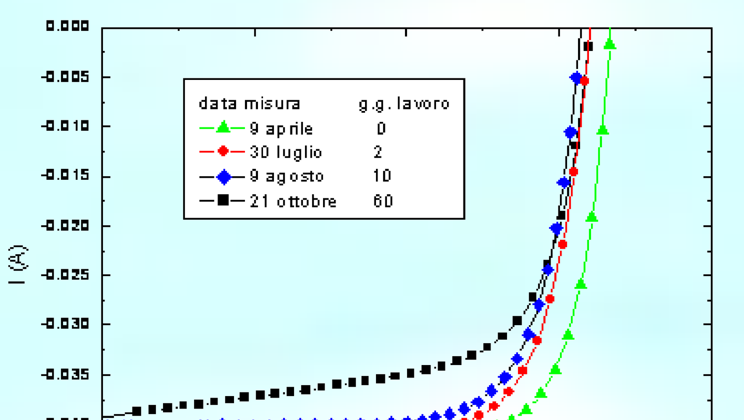
The fluxmeters were tested on the trough concentrator of the Solar Plant (PCS) located at ENEA-Casaccia Laboratories (Rome) [2]. The concentrator (see the photos above) operates at 40-50 suns and is characterized by a trough geometry with 590 cm aperture and 181 cm focal length. The mirror panels are of 120 cm length, assembled in modules of 12 m length. The photos below show the sensor FVC2 mounted on the glass tube near one of the arms supporting the receiver. The sensor head of the fluxmeter is collar shaped, in such a way to be easily wrapped round the 125-mm diameter glass tube protecting the 70-mm diameter stainless steel receiver, placed under vacuum.



The FVC1 sensor was tested in a long campaign in the field, with continuous monit photocurrent and temperature and for different orientations. In the figure below on left th direct solar radiation is compared to that of concentrated radiation on the cell i measurements. The simultaneously measured temperature is reported in the figure below



The FVC1 cell reached temperatures (>160 °C) well higher than that recommen manufacturer (100 °C). The cells were then periodically tested in the lab for measuring curve. No detectable degradation was observed after two weeks of exposition, wherea degradation was observed after two months of direct exposition, which had little effect photocurrent measurements (see Fig. 3). The test campaign carried out on the FVC proved the suitability of the sensor to sustain the maximum radiation flux densities, th diffuser windows and to the cooling fan. All the tests in the field, in fact, showed that th average cells temperature maintained always at around 60-80 °C. Light I/V curve tests ma after a long period of exposition showed no appreciable degradation of the eleven cells.



CONCLUSIONS

Solar concentration cells from SunPower tested as photodetectors in fluxmeters for thermal concentrators operating at ~50 suns Cells directly exposed to the concent radiation reached temperatures in excess o worked well without appreciable degradation