OPTIMIZATION OF THE OPTICAL COMPONENTS IN A REFLECTIVE HIGH CPV MODULE

Luisa Sciortino[1], Simonpietro Agnello[1], Marco Barbera[1,2], Gaetano Bonsignore[1], Marco Cannas[1], Alfonso Collura[2], Franco Mario Gelardi[1], Ugo Lo Cicero[2], Fabio Maria Montagnino[3], Filippo Paredes[3], Luisa Spallino[1].

[1] Dipartimento di Fisica e Chimica, Università di Palermo, Via Archirafi 36 ,90123 Pa, Italy, luisa.sciortino@unipa.it

[2] Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Palermo, Piazza del Parlamento 1, 90134 Palermo

[3] IDEA s.r.l., Termini Imerese (PA), Italy

1. Abstract

The employment of highly concentrated sunlight is a competitive recipe to significantly reduce the cost of energy production with respect to planar PV systems, nevertheless the choice to use high flux radiation entails a series of contrivances in order to minimize the ageing of the components and to reduce the losses of radiation along the sunlight path. Here we report our approach to optimize an HCPV module based on reflective optics and III-V multi-junction cells [1]. In our high CPV module based on a paraboloid reflective optics concentrator and a secondary optic element (SOE) lightpipe (frustum) most of the radiation losses are ascribable to:

- the intrinsic reflectivity of the paraboloid mirror;
- the deposition of inorganic and organic dirt on the concentrator;
- the transmission properties of optical material and of the geometry of the frustum;
- the deposition of inorganic and inorganic dirt on the exposed base of the frustum;
- the transmission and the ageing of the encapsulant material that couples the frustum to the multi-junction cell.

The following activities have been undergone to tackle each one of these critical items and choose a good combination of materials and components that minimize loss of radiation and diminish ageing in our high CPV module:

- We have selected an ultra clear float glass coated with silver for the commercial paraboloid mirrors and have compared the performances of two mirror thicknesses (3 mm and 4 mm) by measuring the normal incidence reflectivity at 650 nm, and the efficiency of the light concentration by a full paraboloid surface (45cm × 45cm).
- It is well known that dust and soil deposited on the mirror surface absorb light decreasing considerably the reflectivity, for this reason the use of a self-cleaning coating is advised [2]. To test the efficiency of self-cleaning coatings, made up of silica and titania nanoparticles, a series of mirror tiles, on which the coatings were deposited, have been exposed to atmospheric agents for months and the reflectivity at 650 nm has been measured up to a timescale of about half an year to check the effectiveness of the deposited coatings which indeed exhibit either hydrophilic or hydrophobic behaviours.
- We investigated two materials for the frustum, namely, an ultrapure silica from sol-gel synthesis and a borosilicate glass also known as BK7, studying the optical transmission between 190 and 900 nm.
- The optical transmission of the frustum can be reduced by dirt deposited on its larger base. In order to determine whether this effect is significant, we have measured the efficiency of some III-V multi-junction cells coupled with dusty frusta.
- While cleaning of the optics components such as mirrors and frusta, if necessary, could be assured by human action, the lifetime of the encapsulant, both in terms of optical transparency and mechanical robustness under high radiation/thermal stress is an annoying problem [3]. In the manufacture of CPV module an adhesive is required to bond the frustum, made up of silica, and the photovoltaic cell. The adhesive must exhibit thermal stability, must be optically clear and should show a refractive index, n, higher than that of the silica (n = 1.55) and lower than that of the InGaP (n = 1.8). We have investigated different encapsulant available on the market and have compared the optical transmission freshly after curing and then after thermal and radiation stresses.

These topics are actually under investigation in the framework of the Fotovoltaico ad Alta Efficienza (FAE) project (PO FESR Sicilia 2007/2013 4.1.1.1).

References

[1] FAE: A CPV-CHP SYSTEM AT CONCENTRATION 2000 TO PRODUCE ELECTRIC POWER AND HEAT presented in this conference CPV-10.
[2] I.P. Parkin, R.G.Palgrave "Self-cleaning coatings" J. Mater. Chem., 2005,15, 1689-1695.
[3] M.D. Kempe "Accelerated stress testing of hydrocarbon-based encapsulants for medium-concentration CPV applications" Photovoltaic Specialists Conference (PVSC), 2009 34th IEEE.