CERAMIC TILES SURFACE FUNCTIONALISATION BY PHOTOVOLTAIC CELLS

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ABSTRACT

In the Italian Ceramic Centre, the specialised CECERBENCH Laboratory was established to study and develop building ceramics with a functional surface. This Laboratory was assigned the task of providing technical assistance and continuous support not only to the Emilia-Romagna Region ceramic tile producers, but also to other Italian and foreign producers, so enabling them to master the fabrication technologies of final products with high added value.

The CECERBENCH Laboratory focuses on the development of ceramic tiles that have unusual surface properties and, consequently, high market potential. Initially, its work has been devoted to the development of outdoor ceramic wall tiles with a surface able to generate electricity through the photovoltaic effect.

1. INTRODUCTION

The CECERBENCH laboratory, dedicated to the development of ceramic tiles with functional surfaces, was set up within the Ceramic Centre of Bologna. The aim is to meet the ceramic tile manufactures needs, and develop new products that, while maintaining their aesthetic and functional characteristics, have new functions, e.g. self-cleaning, fotoactive, antibacterial, catalytic, etc.

Initially, the research activities have concentrated on the development of processes and unitary operations to make a ceramic tile for external building walls, able to convert solar energy into electric energy by exploiting the photovoltaic effect. Of course, these tiles maintain their basic role of thermal building insulation, since they are used as buildings coverings.

Research at the CECERBENCH laboratory involves: (1) the development of coating materials that can act as photovoltaic cells for application onto tiles, (2) the development of ceramic oriented technology to produce, together with the firing of ceramic substrate, coatings able to transform sunlight into electric power and (3) the development of guidelines for the use of "photovoltaic" tiles for building coverings. The transfer of the developed technologies to ceramic tile manufacturers will provide them with new opportunities for product diversification.

2. RESEARCH ACTIVITIES PLANNING

To achieve the envisaged objectives, the project was structured through five Work Packages (WP): for each of these, R&D activities were planned by nine tasks. The flow sheet of the project is shown in figure 1.

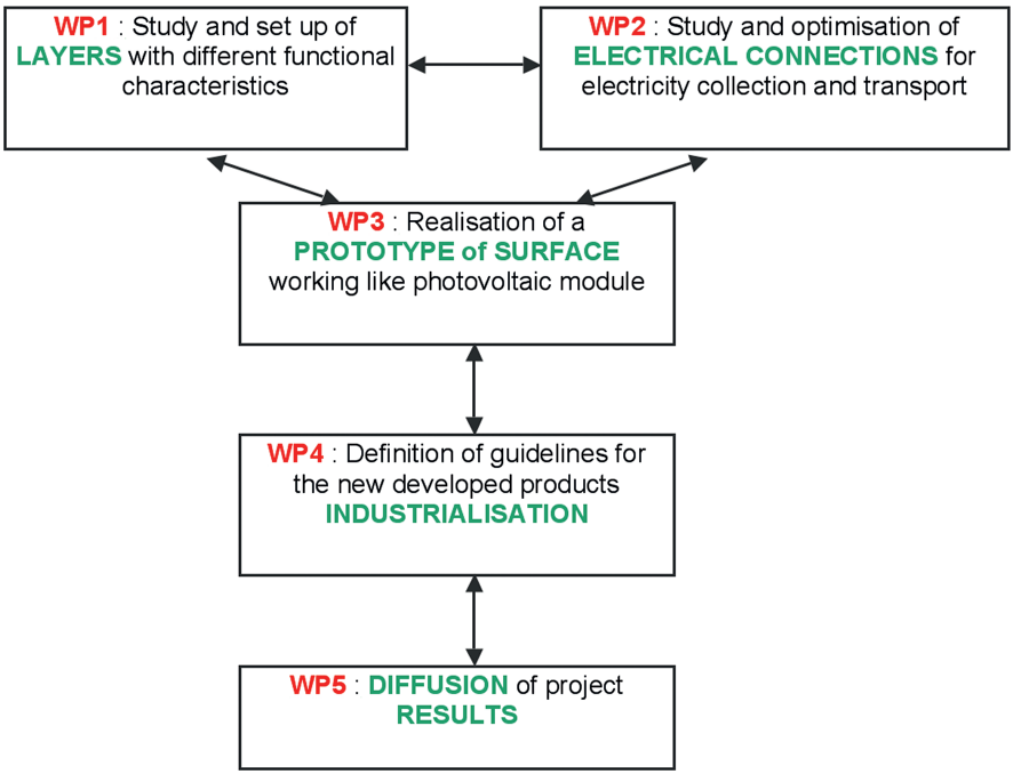

Figure 1. Flow Sheet of the project.

The innovation consists of the study and development of materials and related technologies to make a "photovoltaic surface" directly within the current ceramic tile process. The aim is to preserve the aesthetics and other technical characteristics, and to create new surfaces to increment the use of renewable energy source.

In the first project step, various processes and techniques were evaluated to make different functional layers, whose behaviour allows the ceramic tile to act as a photovoltaic device. Beside this, other preparation techniques and components were studied to collect and transport the electric energy to allow development of the contacts between the cells on a tile and the junctions among the tiles (see figure 2).

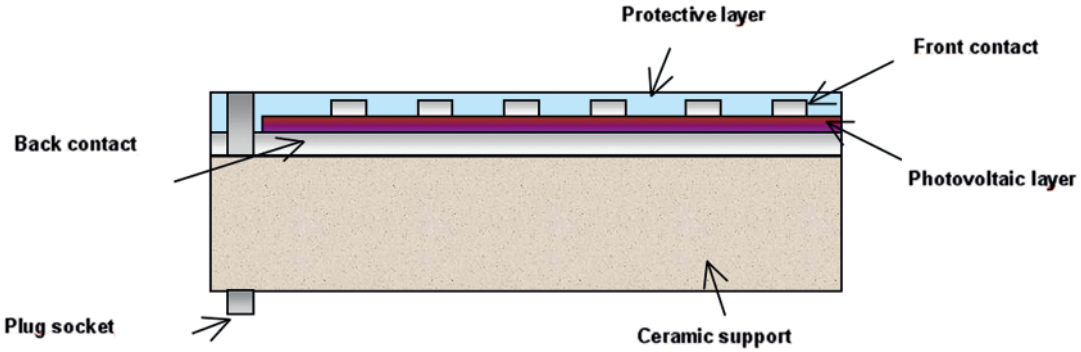

Figure 2. Scheme of photovoltaic ceramic tile.

3. RESULTS AND DISCUSSIONS

To produce the photovoltaic layer replacing the glaze layer directly on the ceramic substrate, *thin film* technology was used. In particular, to obtain results in a short-medium time, the amorphous Silicon technology was selected.

Initially, as a reference, the a-Si cells, having an area of 1x1 cm^2 , were deposited on a glass support (see figure 3a). The J-V relationships under illumination, measured at 100 mW/cm^2 and AM1.5G irradiance, are reported in figure 3b.

Then, the support was changed, and a ceramic substrate was used (figure 4a). With 1x1 cm^2 PV cells, an efficiency similar to that of cells made on the glass substrate was obtained (figure 4b).

To fabricate solar cells able to produce a higher power, bearing in mind a future industrialisation, we moved from small area cells to large area cells, using the same device structure and the same techniques.

The unit photovoltaic cells (4 cells, size 7x1 cm^2) are connected in series and the photocurrent is afterwards conveyed toward the tile with an incorporated plug-socket device enabling an easy interconnecting with the neighbouring tiles.

Thus, the prototype of "photovoltaic tile" (see Figure 5a), operating as a mini PV module was realised. The J-V curve of this module is reported in figure 5b.

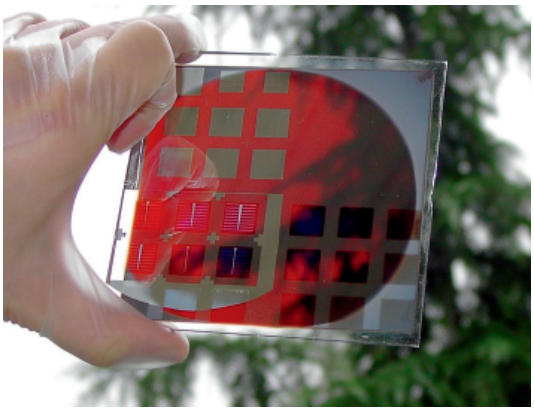

Figure 3a. Reference PVells deposited onto glass substrate

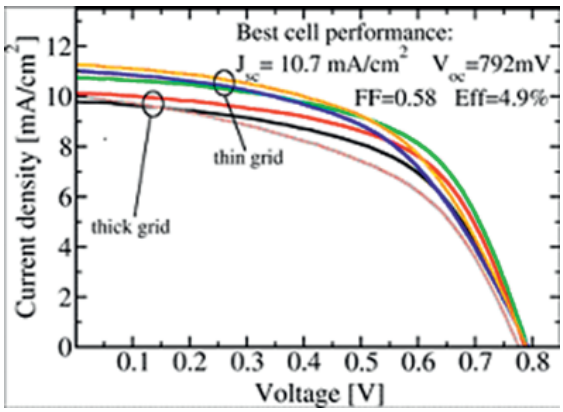

Figure 3b. J-V characteristics of single PV cells onto glass substrate

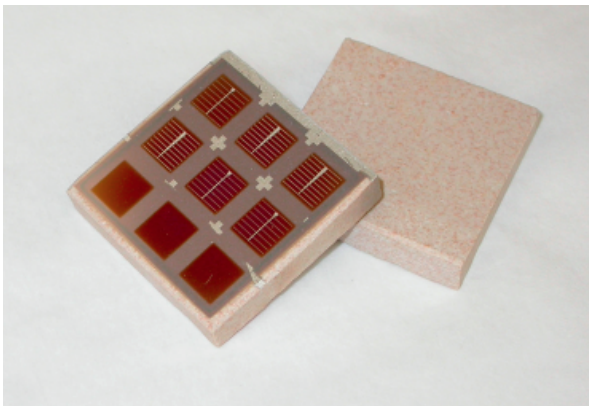

Figure 4a. Small PV cells deposited onto ceramic substrate

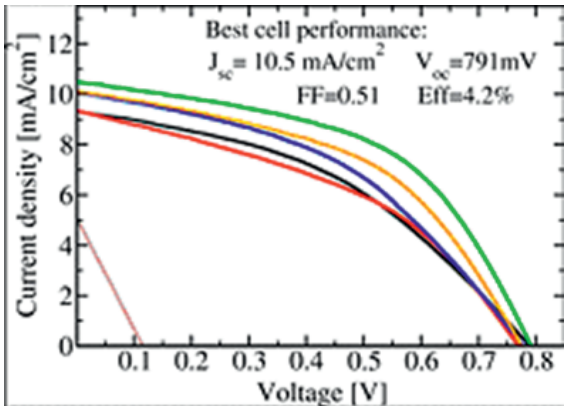

Figure 4b. J-V characteristics of PV cells onto ceramic substrate

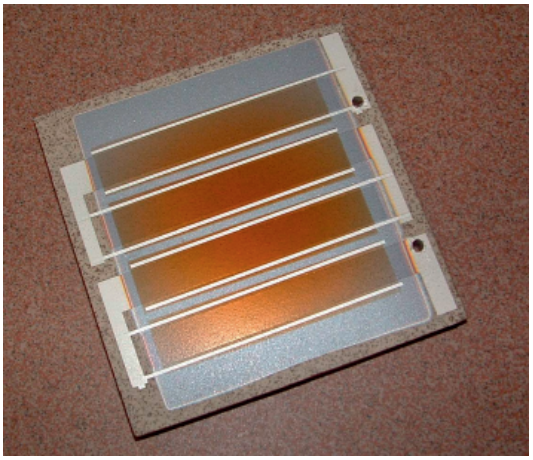

Figure 5a. Mini-module, with large area PV cells, onto ceramic substrate

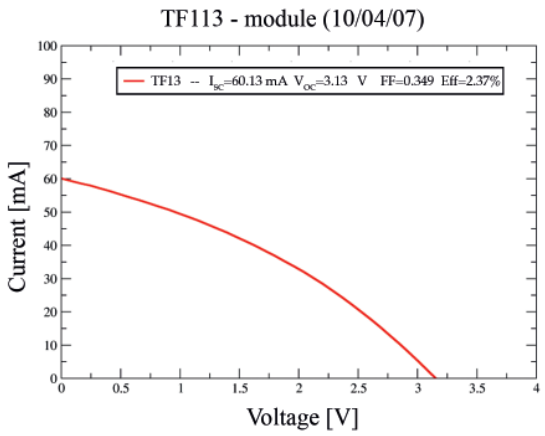

Figure 5b. J-V characteristic of mini PV module on ceramic tile

4. CONCLUSIONS

The activity of the CECERBENCH Laboratory had allowed a ceramic tile to be functionalised, developing surface able to generate electricity through the photovoltaic effect.

For the first time, the possibility of depositing a-Si thin film PV devices directly onto a ceramic tile has been demonstrated.

The main result obtained to date is, undoubtedly, the prototype shown at the R2B (Research To Business) exposition, on 4th-5th May 2007, in Bologna, and the filing for its Patent.