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CERAMIC TILES SURFACE FUNCTIONALISATION BY PHOTOVOLTAIC CELLS

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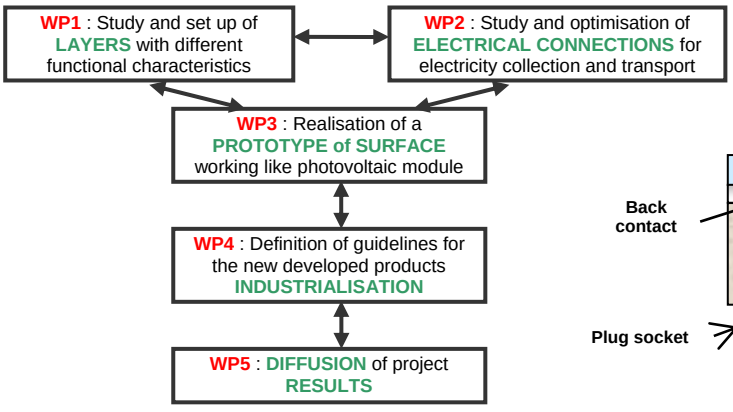
Abstract
Within Italian Ceramic Centre it was established the Laboratory CECERBENCH specialised to study and develop building ceramics having a functional surface. To this Laboratory it was assigned the task to offer technical assistance and continuous support not only to the Emilia-Romagna Region ceramic tiles producers, but also to other Italian and foreign producers, so enabling them to master the fabrication technologies of final products having high added value.
The Laboratory CECERBENCH is directed towards the development of ceramic tiles having unusual surface properties and, consequently, high market potential. Initially, its work was devoted to the development of outdoor wall ceramic tile having the surface able to generate electricity through the photovoltaic effect.

Introduction
The laboratory CECERBENCH, dedicated to the development of ceramic tiles with functional surface, was set up within Ceramic Centre of Bologna. The aim is to meet the ceramic tiles manufactures needs, to master new products that, even maintaining their aesthetic and functional characteristics, have new function, e.g. self-cleaning, fotoactive, antibacterial, catalytic, etc.
At the beginning the research activities has been concentrated onto the development of processes and unitary operations to make a ceramic tile, for building external walls, able to convert the solar energy into electric one by exploiting photovoltaic effect. Of course, these tiles maintain their basic role of building thermal insulation, since they are used as buildings covering.
Research at CECERBENCH laboratory involves: (1) the development of coating materials suitable to act as photovoltaic cells to be applied onto the tiles, (2) the development of ceramic oriented technology to produce, contemporaneously with the firing of ceramic support, coatings able to transform sunlight into electric power and (3) the development of guidelines for the use of “photovoltaic” tiles for buildings covering. The transfer of the developed technologies to ceramic tiles manufacturers will provide them with new opportunities for products diversification.

Research Activities Planning
To achieve the envisaged objectives, the project was structured through five Work Packages (WP): for each of them R&D activities were planned by nine tasks. The flow sheet of project is shown in Fig.1.
The innovation consists in study and development of materials and related technologies to make a “photovoltaic surface” directly within the actual ceramic tiles 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, which behaviour allow the ceramic tile to act like a photovoltaic device. Beside this, other preparation techniques and components were studied to collect and transport the electric energy enabling to develop the contacts between the cells on a tile and the junctions among the tiles (see Fig.2).



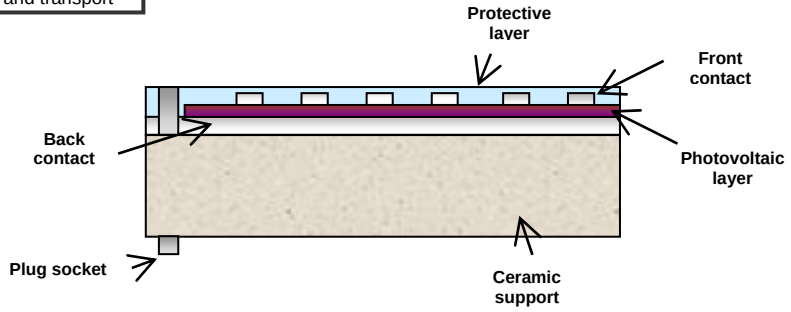


Fig.1: Flow Sheet of the project

Fig.2: Scheme of photovoltaic ceramic tile

Results and discussions

To produce the photovoltaic layer directly on ceramic substrate replacing the glaze layer, the *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 one, the a-Si cells, having an area of 1x1 cm^2 , were deposited on a glass support (see Fig.3a). The J-V relationships under illumination, measured at 100 mW/cm^2 and AM1.5G irradiance, are reported in Fig.3b.
Then, the support was changed, and a ceramic one was used (Fig.4a). With 1x1 cm^2 PV cells, an efficiency similar to that of cells made on glass substrate, was obtained (Fig.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 incorporated plug-socket device enabling an easy interconnecting with the neighbouring tiles.
So, the prototype of "photovoltaic tile" (see Fig.5a), operating as a mini PV module was realised. The J-V curve of this module is reported in Fig. 5b.

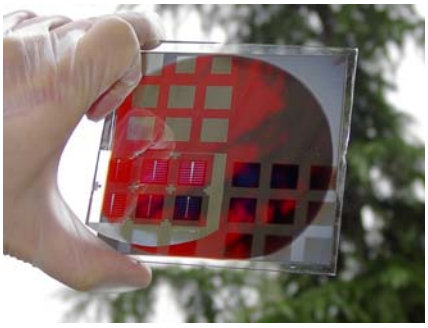


Fig.3a: Reference PVells deposited onto glass substrate

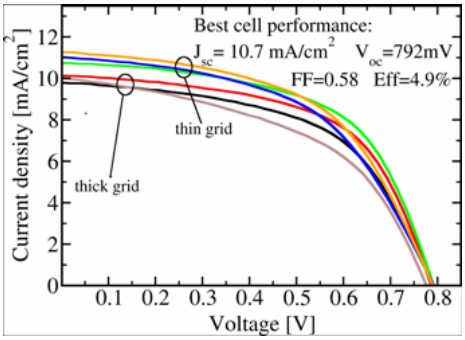


Fig.3b: J-V characteristics of single PV cells onto glass substrate

Fig.4a: Small PV cells deposited onto ceramic substrate

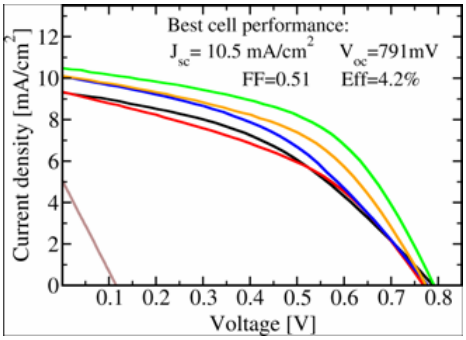


Fig.4b: J-V characteristics of PV cells onto ceramic substrate

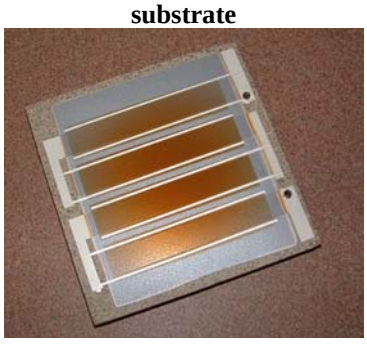


Fig.5a: Mini-module, with large area PV cells, onto ceramic substrate

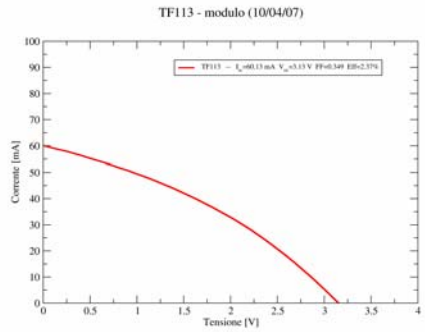


Fig.5b: J-V characteristic of mini PV module on ceramic tile

Conclusions

The activity of Laboratory CECERBENCH allowed to functionalise a ceramic tile, developing surface able to generate electricity through the photovoltaic effect.
For the first time, the possibility to deposit PV devices a-Si thin film based directly onto a ceramic tile is demonstrated.

The main result obtained up to now is, doubtless, the prototype showed at R2B (Research To Business) exposition, on 4th-5th of May 2007, in Bologna and the filing for its Patenting.