THE INVISIBLE HIDDEN PV

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ABSTRACT: The integration of PV modules in buildings maybe represents the most acceptable application of PV. The only drawback is the aesthetical impact due to the installation and the look of the building and of the nearby is considered somehow compromised and get worse for the presence of the PV components. Especially for historical towns the strong modification of the traditional outlook could result a very serious obstacle for the general acceptance of the PV technology and very often authorities deny the permission for its installation.
Keywords: Building Integrated PV (BIPV), Ceramic Substrate, Reliability

1 INTRODUCTION

The integration of PV modules in buildings maybe represents the most acceptable application of PV. The only drawback is the aesthetical impact due to the installation and the look of the building and of the nearby is considered somehow compromised and get worse for the presence of the PV components. Especially for historical towns the strong modification of the traditional outlook could result a very serious obstacle for the general acceptance of the PV technology and very often authorities deny the permission for its installation.

The purpose of this work is to present an innovative PV component that can easily be manufactured in form of buildings products, such as tiles or stones or concrete, that are indistinguishable from the traditional ones but can produce electrical energy, thanks to the introduction of photovoltaic elements just inside the component

The innovative concept of this component is that the PV cells are hidden inside the components where they are covered by a special plastic material similar to the material the component is made of; the active area is camouflaged but the light is allowed to enter into the material, to be scattered and diffused inside it, then hit the PV cell and finally generate power.

The use of that technology can be applied on every building's component such tile, stone or concrete. The implementation is very general and could be tailored according to the laws and regulation of the site.

That original idea was realised by Giovanni Battista Quagliato of Dyaqua Art Studio that won the national Italian contest "Sun, wind and sea"; at this moment its patent is pending.

Thanks to that idea new components for building could fully be hidden inside apparently traditional components that are active; they can be easily manufactured and largely and profitably used for building integration especially in highly values urban context.

Starting from that idea some preliminary tests have been carried over in our laboratory on some samples. The results are encouraging, considering that they are the first being manufactured at a very handicraft scale; the experimental evidence is that they work although the behaviour is not yet well optimised as it could be imagined. A tile of size approximately 717 cm^2 dimension has produced 2.2 Wp giving an efficiency of about 3 % over the projected tile area. A stone of size approximately 187 cm^2 has generated even less power, 0.3 Wp, with an estimated efficiency of about 1.6 %. Next steps will be the improving of the electrical performance by a more accurate design and choice of the active cell and the optimization of more reliable steps for realization of the component in a process closer to industrial level; at the same time tests of reliability derived by the IEC 61215 or IEC 61646 will be carried over to investigate about possible infant mortality.

At this moment the status of the art is basically an idea or just a bit more. Preliminary tests over not optimised samples seem to demonstrate the acceptable quality of the component. But the idea works and the successive steps will be the optimization of a process and the production of a prototype. At the same time tests of other components will be provided in order to verify their quality and reliability. A balance of the pros and cons from technological, economical and strategic points of view will be also considered in the study.

2 SAMPLES

2.1 The PV tile

A sample in form of PV tile was prepared. The picture 1 shows how it can be indistinguishable from traditional tiles.

Figure 1: The indistinguishable PV TILE just in the middle of a roof

The sample was characterized at STC; figure 2 shows the IV curve and table I reports the electrical values.

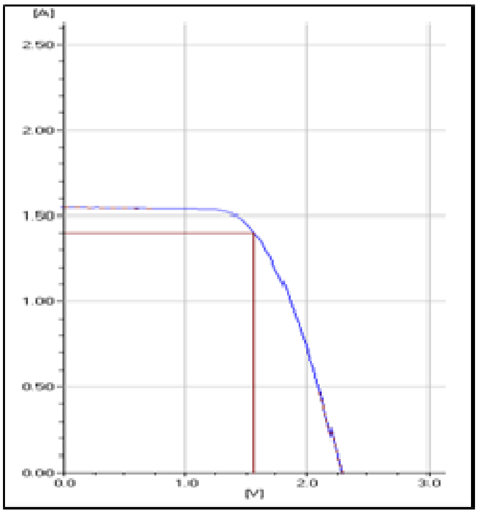

Figure 2: Measurements at STC of the PV tile

Table I: Electrical values for the PV tile

Isc (A)	Short circuit current	1.55
Voc(V)	Open circuit voltage	2.3
Pp (W)	Peak power	2.2
Ipp (A)	Peak power current	1.40
Vpp (V)	Peak power voltage	1.6
Fill factor (%)	Fill factor	61.9
Module η (%)	Module's efficiency	3.07
Cell η (%)	Cell's efficiency	4.51

Figures for 3 to 6 show the results of electrical test in dark conditions.

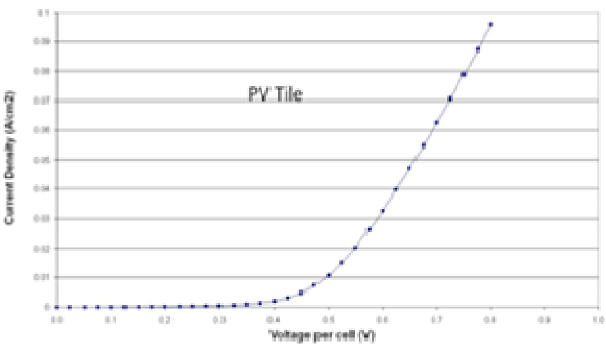

Figure 3: Dark IV curve for the PV tile

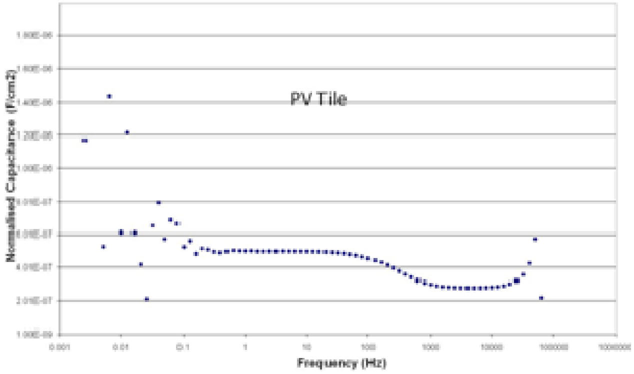

Figure 4: Capacitance vs. frequency of the PV tile

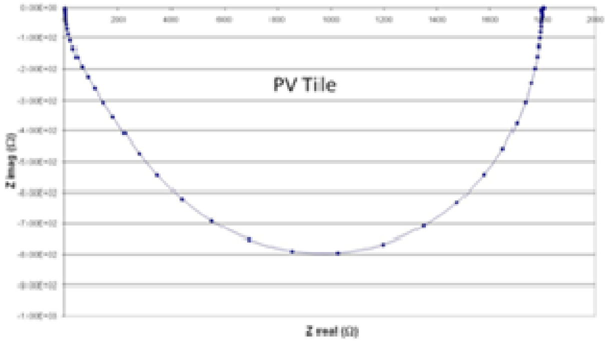

Figure 5: Nyquist diagram for the PV tile

2.2 The PV stone

A sample in form of PV stone was also prepared. The figure 6 shows how it can be indistinguishable from traditional stones

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Figure 6: The indistinguishable PV stone

The sample was characterized at STC; figure 7 shows the IV curve and table II reports the electrical values.

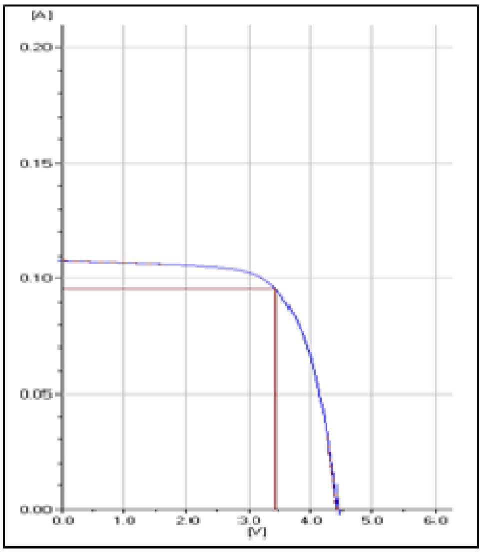

Figure 7: Measurements at STC of the PV stone

Table II: Electrical values for the PV stone

Isc (A)	Short circuit current	0.11
Voc(V)	Open circuit voltage	4.4
Pp (W)	Peak power	0.3
Ipp (A)	Peak power current	0.10
Vpp (V)	Peak power voltage	3.4
Fill factor (%)	Fill factor	68.3
Module η (%)	Module's efficiency	1.60
Cell η (%)	Cell's efficiency	2.08

Figures for 8 to 10 show the results of electrical test in dark conditions.

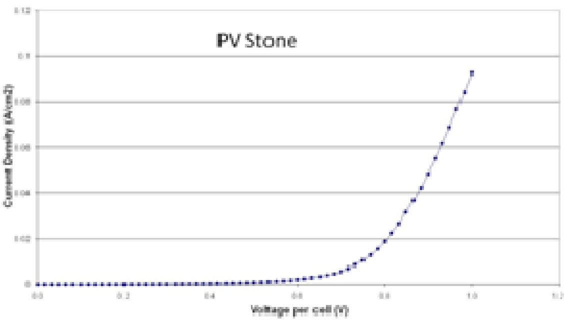

Figure 8: Dark IV curve for the PV stone

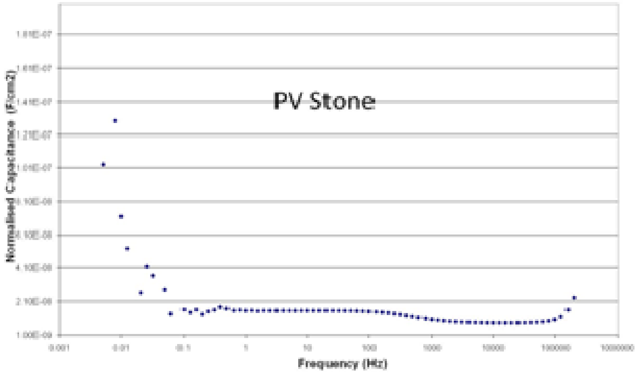

Figure 9: Capacitance vs. frequency of the PV stone

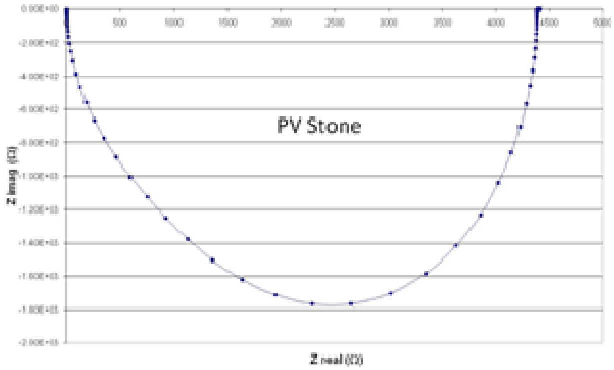

Figure 10: Nyquist diagram for the PV stone

3 AGEING

Both samples were subjected to a cycle of ageing complying the Standarda IEC and IEC 61215. The salt mist corrosion test was passed successfully but they failed at the humidity freeze test. A very large horizontal crack was produced in the stone as shown in fig. 11 and different and very deep clefts and cracks lesions appear in the tile as shown in fig, 12. The problem seems to relay on the porosity of the substrate that fills the water during the humidity step and when the temperature reaches values below the 0°C due to the expansion of ice the disrupt the structure and delaminate the sample.

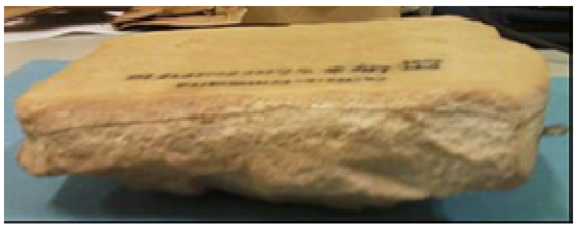

Fig. 11 A very large horizontal crack produced within the stone

Fig. 12 Different and very deep clefts and cracks lesions within the tile.

4 RESULTS

The experimental data shown in chapter 2 indicate that from an electrical point of view the objects are not very effective. Dark measuremnts confirm that the electrical values are not optimised. The results obtainsd by the firss test on eliability demonstrate that problems with humidity penetration are to be faced. Nevertheless they are the first samples not even prototypes. A second set of samples where the substrats was treated by special lque was prepared and it is under investigation now.

5 CONCLUSIONS

At this moment the status of the art is basically an idea or just a bit more. Preliminary tests over not optimised samples seem to demonstrate the acceptable quality of the component. But the idea works and the successive steps will be the optimization of a process and the production of a prototype. At the same time tests of other components will be provided in order to verify their quality and reliability. A balance of the pros and cons from technological, economical and strategic points of view will be also considered in the study.