INNOVATIVE SOLUTION FOR BUILDING INTEGRATED PHOTOVOLTAICS

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ABSTRACT

Among the main challenges of our century, the climate change and the need of diversification of the energy sources are of most importance. Renewable energies undoubtedly have an important role to play, photovoltaic (PV) electricity being especially well suited to face these energy challenges. However, the current integration of PV panels often comes without architectural consideration. In this context, the Archinsolar project [1] aims to develop a new generation of photovoltaic elements based on silicon thin films technologies (amorphous and micromorph), ultra-reliable and manufacturable at a very low cost, allowing a unique architectural integration, respectful of the built environment and overall landscape. Here we will present our new developments on innovative PV elements including colored PV panels and a solar tile using a composite back-structure.

GENERAL CONTEXT

The renewed debate on nuclear energy following the recent events in Japan, the numerous political decisions made in favor of the development of renewable energies as well as the attitude of the public, which is always more concerned about environmental issues, lead to the development of new and more adequate technologies adapted to our current energy needs.

Photovoltaic energy is particularly well positioned as it is proven that a large part of the electricity needs of our modern society could be covered by photovoltaics, providing intelligent energy management if applied. In the long-term, solar energy should even be used to provide a significant part of the world's energy consumption. As an example, the well oriented roofs of Switzerland (130 km^2) could cover around $1/3^{rd}$ of the 58 annual TWh with standard crystalline modules.

It is then reasonable to argue that, today, there is no "versatile" solution available on the market which is inexpensive, aesthetically acceptable and easy to install. Nowadays photovoltaic energy is still limited by to heavy investments. These investments are notably associated to the unit prices, to the BOS costs (mounting, support, inverter) and to the

planning costs (linked to the experience). Indeed, the price of the modules proposed on the market is still one of the most important factors which retain potential purchasers. In the built-environment and in specific landscape, aesthetic aspects will play an increasingly important role, as the pressure not to install PV in areas reserved to agriculture is increasing.

These crucial aspects are of utmost importance to succeed in competitively positioning photovoltaic energy either on the electricity market or for internal use. Only then photovoltaic electricity will be able to contribute significantly to the general electricity production.

SIMPLICITY OF INSTALLATION AND MULTI-FUNCTIONALITY FOR LOWER COSTS

Technologies based on thin-films such as amorphous or microcrystalline silicon [2-3], have the potential to lead to a stronger cost reduction of the solar kWh (<30€/m^2 for the thin layers) and offers the unique potential to cover large surfaces at a particularly low cost. Furthermore, thin film Silicon technology is based on abundant and non hazardous materials.

To reduce the high expenses related to the installation of photovoltaic modules, solutions to simplify the installation of system is required. Currently, an installation of photovoltaic modules on a roof remains complex and needs the intervention of several working corporations, from engineers to roofers. A general simplification of the systems, in particular an improvement of the mechanical stability and a simplification of the electrical connections are taken into consideration. Furthermore, the size and the weight of the module, using composite materials [4] is taken into account and should be adapted to allow only one roofer to be able to install the system.

Integration solutions allowing the replacement of other building components by photovoltaic panels will reduce the overall cost of the installed system. Simple and modular building elements such as roof tiles and slates, or solar roof windows (semi-transparent), and other components are certainly the most innovative aspects. These elements should then ensure multifunctionality such as mechanical stiffness, water vapour barrier [5-6], building element, insulation, sun protection or capturing the heat energy in addition of solar power generation.

SOLAR TILES WITH COMPOSITE BACK-STRUCTURE

Solar tiles based on thin film silicon technology and a new thermoplastic composite backing structure were introduced as cost-effective solutions fully compatible with building integrated PV. The molded back-structure provides mechanical stability to the module and protects the fragile glass solar cell. It moreover ensures water tightness to the roof by its specific profile. A novel integrated process approach was introduced, in which the lamination step of the glass module to the composite backing (Fig.1. right) is suppressed by direct overmolding of the composite backing on the glass with or without adhesive layer (Fig. 1. left). The main challenges of this new molding process are i) the risk of breaking the glass due to thermal shock during the molding process and ii) durability issues in case no adhesive is used. A small series of solar tile demonstrators were produced and mounted together with TEGALIT tiles on a real size mock-up roof (Fig. 2). The cost and environmental impacts for the production of these novel BIPV compatible solar tiles were evaluated and found to be comparable with standard rack-mounted glass-glass modules.

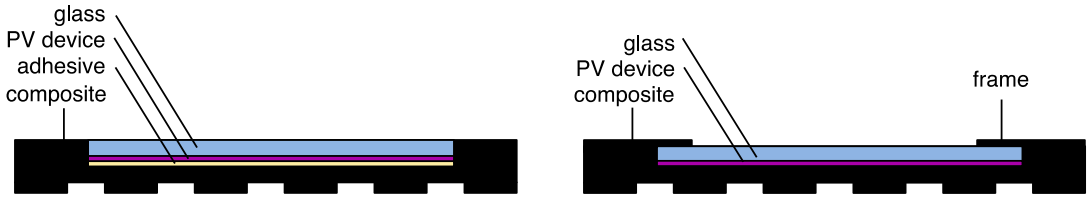

Fig.1. Standard lamination (left) and integrated process (right).

Fig. 2. New solar tiles developed in the Archinsolar project framework

ARCHITECTURAL ASPECTS AND AESTHETICS OF THE PV MODULES IN THEIR ENVIRONMENT

From an esthetic point of view, the color variation, going from the typical brown of amorphous silicon to the typically black for micromorph, constitutes one of the great starting advantages of these kinds of modules.

The desire for optimum equipment performance is sometimes in conflict with site and building conditions. While effective in establishing proper orientation of solar panels, these installations give a discontinuity in the building and its architecture.

Providing architects with a pallet of various products, with amongst other aspects, different color levels, is essential. In the long term, we can imagine that every roof could be completely covered with suitable tainted photovoltaic modules and cost effective. Due to the inherent homogeneous aspect of the thin films based modules, as well as the possible modification of these colors by the introduction of colored filters [7-8] or polymers, it is possible to consider a whole pallet of modules aesthetically interesting which will be better integrated in their environment.

COLORED PV ELEMENTS

A new generation of orange coated glasses with improved angular color stability have been industrially produced on large glass panes by Swissinso S.A. and laminated to real-size (1.10 x 1.30 m2) PV a-Si modules (Fig.3).

Fig. 4: Orange glass panes laminated on real-size PV modules (1.10 x 1.30 m^2) on which strong angular dependency of the color is observed.

In parallel, new terra-cotta like modules have been developed, using a specific encapsulation scheme without additional coating. These new framed terra-cotta like PV modules have been installed on a demonstration roof at IMT (Fig.4) and show a perfect integration by their color and the water tightness ensured by the special design of their frame. This allow, in addition, a very easy mounting without any special preparation of the roof underneath. The max-Power voltage of these modules if of 107 V with an efficiency of 6%.

Fig. 4: Demonstration roofs with the new orange colored PV modules

CONCLUSION

Only a very small fraction of the installed PV capacity has been actually integrated in the built environment. Landscape protection, competition with agricultural lands or public opinion are putting pressure on PV developers to increase the use of the build environment as a space to produce PV electricity. At the same time, higher module and/or BOS (Balance Of System) costs when installing on buildings and poor aesthetics of several existing PV integration are additional elements working against PV on buildings. There is therefore a necessity to come up with new PV modules addressing the two major barriers against a wider spread of PV in the build environment: cost and aesthetics.

Innovative coloured solar tiles were developed and shown on full size demonstrator in this project. The results presented here clearly show the potential for developing innovative PV systems allowing improved architectural integration by developing coloured PV modules, either using interferential coloured filters on thin film amorphous silicon modules or by working on different cell and encapsulation designs. These multifunctional BIPV solutions, especially when based on thin film technologies are extremely promising and cost effective if compared to conventional building elements.

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