Building Integrated Photovoltaics (BIPV); Advanced materials for construction

The days of seeing solar photovoltaic modules mounted on the rooftop of buildings are numbered- why mount them on the building when you can integrate them directly into the construction material itself? Photovoltaic solar cells, which convert sunlight to electricity, are taking on a new form and will blend seamlessly into the building design. This article reviews the current state-of-the-art in BIPV, the potential market growth and the major market players.


Solar tiles integrated in a rooftop[1]

In recent years it has become common place to see solar photovoltaic modules mounted on the rooftop of buildings; the electricity they produce can lower the consumption from the grid and reduce the carbon footprint. Advancements in materials science are leading to the development of new photovoltaic construction materials which can be directly integrated into building rooftops, windows and facades.[2]

> Building Integrated Photovoltaics (BIPV) replaces some of the typical buildings materials such as the roof tiles or the wall cladding with photovoltaic materials, enabling the building structure itself to produce electricity.

Integrating photovoltaics into the building structure puts stringent demands on the functionality of the materials. Apart from producing electricity in the presence of sunlight and offering a guarantee of at least 25 years, BIPV products need to be able to offer at least one additional functionality; such as weather proofing or noise insulation. The commercial technology is based on either crystalline silicon or thin film solar cells.

CRYSTALLINE SILICON

Crystalline silicon is currently the most established technology, dominating 90% of the market. An important parameter to consider is the energy conversion efficiency, which is the efficiency with which the solar cells convert the incoming solar energy into electricity. A higher efficiency means more electricity is produced per solar cell or per unit area, which is particularly important for installations where the space is limited. Crystalline silicon currently offers the highest energy conversion efficiency; commercial modules typically convert 13-21% of the incident sunlight into electricity. The solar cells can be encapsulated into glass to make solar facades replacing traditional cladding, or mounted in glass-glass laminates to make skylights and semi-transparent roofs. The spacing between the solar cells can be tailored to control the amount of light that passes through the skylights. For rooftop applications the solar cells are mounted using “smart mounting systems” which replace sections of the roof. Alternatively they can be laminated and integrated into the roof tiles, replacing traditional roof tiles. Anti-reflection coatings help to capture the sunlight, and the thickness of the coating can be varied to produce solar cells in different colours, allowing architects to incorporate colour into their building designs.


Polycrystalline wafers coated with different anti-reflection coatings.[4]


BIPV crystalline silicon skylights.[3]

THIN FILM SOLAR

Thin film solar can be lightweight in comparison to crystalline silicon (depending on how it is mounted), and has the advantage that it can be produced as a flexible film. Thin film solar is a popular choice for roofs that have weight constraints, curved roofs, curtain wall BIPV and fabrics.


Thin film solar integrated in a curved rooftop.[2]

The drawback of thin film solar is that the energy conversion efficiency is lower than for crystalline silicon, so a larger surface area would be required to produce the same amount of electricity. A number of different thin film technologies are available on the market, including Copper-Indium-Gallium-Selenide (CIGS), Cadmium Telluride (CdTe) and amorphous silicon. Each technology has its advantages and disadvantages.

> CIGS solar modules currently offer the highest sunlight to electricity conversion efficiency (10-16%) amongst the commercial thin film solar cell technologies.

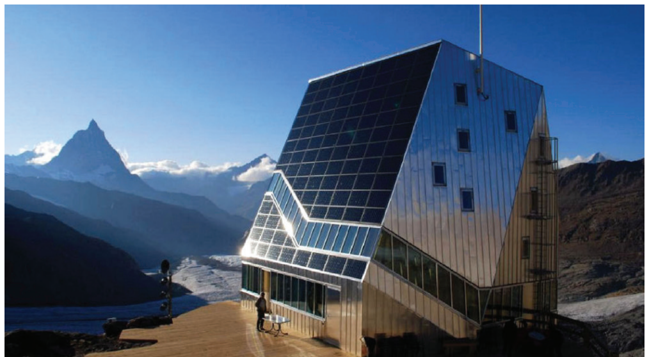
Commercial CdTe solar modules currently offer efficiencies of 9-13%, and amorphous silicon solar modules are typically 6-10%. Amorphous silicon offers the advantage that the thickness can be tailored to produce semi-transparent solar cells, which can be used for windows and facades.

BIPV SUPPLIERS

A number of solar cell and module manufacturers have divisions dedicated to BIPV, so there is a long list of suppliers. Some notable names include *Panasonic Solar*, who bought Sanyo's HIT technology in 2012, and sell the HIT Power Roof®. US-based company *Sunpower* offers the rooftop product SUNTILE®, which is specifically designed for production homebuilders and offers the highest efficiency in production (22%). Japanese company *Sharp Solar* also offers roof integrated solar tiles. In the thin film BIPV category, US based company *Dow Powerhouse* is one of the leaders for CIGS technology with the Dow Powerhouse™ solar shingle system. German high-tech equipment manufacturer Manz AG also offers CIGS solutions for BIPV, and in April 2015 they achieved a world record module efficiency of 16%. Spanish company *Onyx Solar* offers a range of BIPV products including anti-skid PV floors, skylights, facades and curtain walls, amongst others. *Swiss Inso* and *Acomet Solar* have teamed up to offer coloured solar panels based on Swiss patented Kromatix™ technology, which was originally developed at EPFL (Swiss Polytechnic Institute). The coloured solar panels can be integrated into rooftops and building facades. *HyET Solar* produces lightweight thin film solar cells based on amorphous silicon technology using a Roll-to-Roll manufacturing process. The lightweight and unbreakable solar cells are designed for integration into the building envelope as a roofing or facade element. UK-based *PolySolar* offers amorphous silicon thin film glass for BIPV applications. The glass is available in different transparencies and colours. Some manufacturers are beginning to offer fully integrated BIPV solutions, such as *SmartEnergy Renewables.*

FUTURE MARKET TRENDS

Currently BIPV remains a high-end market, typically being implemented in "flagship buildings".



Monte Rosa Hut in Switzerland has a BIPV facade

Crystalline silicon BIPV rooftops

> Future trends predict that BIPV will penetrate into the residential and commercial building markets.

The future for BIPV looks...colourful! Market studies show that the incorporation of various designs and colours into BIPV glass is more appealing to customers. Studies also show that a BIPV product that is more transparent is more likely to penetrate new and larger markets.

> The total market for BIPV is expected to grow from \$2.4 billion in 2014 to nearly \$6 billion by 2017 and nearly \$23 billion by 2021.[5]

FUTURE TECHNOLOGY

There is an ongoing flurry of activity in R&D of future BIPV technologies. The main focus points are on: increasing the energy efficiency, decreasing production cost, improving the low-light performance, simplifying the installation and improving aesthetics.

Third generation photovoltaics technologies such as hybrid Dye Sensitised Solar Cells (DSSCs), and Organic Photovoltaics (OPV), are still in the development phase, but offer great possibilities for the future. For example, the efficiency of OPV has doubled in less than half a decade from 5% in 2007 to over 10% in 2013. These low-cost technologies offer excellent low-light performance, which could have important implications for future indoor lighting.

Another interesting future technology for BIPV is Perovskite "tandem" solar cells, which as well as being low-cost, have the potential to achieve even higher efficiencies than crystalline silicon.

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