“New approaches for BIPV elements: from thin film terra-cotta to crystalline white modules”

Laure-Emmanuelle Perret-Aebi
Photovoltaic Research
A competence center

- Basic research
- Advanced devices

EPFL- PVLAB

- Applied research
- From lab to industry

CSEM PV-center
Photovoltaic in buildings

An incredible potential

In Switzerland, 30% of our electricity needs would be covered by using PV modules (10% efficiency) on well oriented roof (130km²)
Photovoltaic in buildings
An incredible potential

In Switzerland, 30% of our electricity needs would be covered by using PV modules (10% efficiency) on well oriented roof (130km²)

Facades are very interesting and necessary!
Photovoltaic in buildings

not anymore an option

- Positive energy buildings
- MoPEC 2014
Photovoltaic in buildings
Integration & Aesthetic

More than a challenge, a necessity!

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Photovoltaic in buildings

Some numbers

Wood: 150 CHF/m²
Ceramic: 250 CHF/m²
Metal: 300 CHF/m²
Glass: 600 CHF/m²
Marmor: 1000 CHF/m²

Micromorph PV module: 90 CHF/m²
Photovoltaic in buildings
A multidisciplinary challenge

➢ Attractive dedicated modules designed with architects, builders, installers...
  colored modules,
  optical effect,
  size, shape, dummies

➢ Multi-functional building elements
  building skin,
  insulation, ventilated façade,
  windows.
Photovoltaic in buildings
A multidisciplinary challenge

But also...

- Identification of the operational barriers
- Holistic strategies - from industry to implementation
- Legislations and regulators, architects, suppliers, integrators, builders...
- Cultural, societal, emotional barriers

NRP 70 “Active Interface”
Transforming and modifying a standard PV module without touching the core technology is an efficient way to modify overall aesthetics without increasing the module costs.
PV instead of tiles
from lab to fab

2010
Archinsolar project

2013
Development & Integration

Transfer & Industrialization

TODAY
IEC certification and PV label in process

www.userhuus.ch
Terra-cotta PV

Thin-film terra-cotta
Mat or shiny finish
Sizes: full size (1100 x 1400) and small size available

IEC certification and Swiss PV label in process
Photovoltaic in buildings
A test installation in Fribourg
Photovoltaic in buildings

terre- cotta roofs - simulation
And what about white?
White photovoltaic module for building facade

Cool & fresh

Elegant

Fits to any architectural style

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White photovoltaic module
for building facade

>10% efficiency
White photovoltaic modules

How does it work

colored film made with innovative nano-technology

highly efficient solar module

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White photovoltaic modules

How does it work

sun light visible color

infrared rays
HJT solar cells have a particularly high response in the IR part of the spectra.

55% of its current comes from IR (700-1200nm).
• HJT solar cells reach a $V_\text{o}$ close to 730 mV (standard c-Si cell 630 mV)

• Even without the visible part of the spectra, the overall conversion efficiency can be over 10%!
White photovoltaic modules

How does it work

Very stable color at every angle of vision (use of broad-band filters)
White photovoltaic modules

How does it work

- Homogeneous white appearance
- Module efficiency above 11%

<table>
<thead>
<tr>
<th>Sample</th>
<th>$V_{oc}$ (V)</th>
<th>FF (%)</th>
<th>$J_{sc}$ (mA/cm²)</th>
<th>Eff. (%)</th>
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</thead>
<tbody>
<tr>
<td>Reference</td>
<td>0.727</td>
<td>71.8</td>
<td>36.56</td>
<td>19.1</td>
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<tr>
<td>White</td>
<td>0.714</td>
<td>74.7</td>
<td>21.38</td>
<td>11.4</td>
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<tr>
<td>(%)</td>
<td>-1.8</td>
<td>4.0</td>
<td>-41.5</td>
<td>-40.2</td>
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</tbody>
</table>

Cell area (cm²) 243.4
Module area (cm²) 400
White photovoltaic modules
from lab to fab

www.solaxess.ch
Colored photovoltaic modules

Next step

Visible IR

![Graph showing transmittance versus wavelength for different PVB colors in the visible and IR spectrum.]

- PVB Dark Green
- PVB Green
- PVB Yellow
- PVB Orange
- PVB Red
Photovoltaic in buildings
Photovoltaic in buildings
white & color
Photovoltaic in buildings

white & color
White photovoltaic modules
A new building material

From inactive to active building façade!!
White photovoltaic modules

Who did the work
Thank you for your attention.

Swiss PV flag at 10% efficiency