FLEXIBLE ENCAPSULATION WITH BACKSHEETS AND FRONTSHEETS FOR PV APPLICATIONS

Christina Schinagl
Frankfurt, 26th September 2012
COMPANY INTRODUCTION

ISOVOLTAIC

INNOVATIVE BACKSHEETS. PROVEN EXPERIENCE.
Global market and technology leader in the development and production of backsheets for photovoltaic modules

Turnover 2011: approx. 190 Mio. EURO

Employees: approx. 250 at 3 sites

Management: Thomas Rossegger / CEO
Manfred Schlögl / CTO
25 YEARS OF EXPERIENCE IN THE SOLAR MARKET

Founding of ISOVOLTA in Werndorf (AT):
Leading manufacturer of electrical insulation materials and technical composites

1949

Development of high-quality backsheet films for solar cells

1985

ICOSOLAR® 0711 is the first ICOSOLAR® product to be officially launched in the market

1988

Construction of a photovoltaic specialized plant in Lebring (AT)

2005

Expansion of production facilities in Lebring (AT)

2008

Spin-off of ISOVOLTA photovoltaics division and incorporation as stand alone company

2009

New ICOSOLAR® products on the basis of modified polyamide are introduced to the market

2010
COMPONENTS OF A CRYSTALLINE SOLAR MODULE

ICOSOLAR® Backsheets and Encapsulants
Key components of a solar module

ISOVOLTAIC develops, produces and sells flexible composite films for protecting and embedding crystalline and thin film solar cells
BACKSHEETS
WAY OUT OF SCARCITY OF RESOURCES

Improved raw material supply and increased entry barriers due to vertical integration

- TPT backsheet, historically ISOVOLTAIC’s key product, dependent on supply of PVF
- Strong demand growth in 2010 could not be met with PVF supply; substantial excess demand
ICOSOLAR® FOR CRYSTALLINE SI-MODULES

ICOSOLAR® Properties:

- Excellent resistance to atmospheric conditions
- Outstanding electric insulation
- Very good mechanical stability
- Standard colors: white and black, transparent, special colors available

Source: Solarworld
ICOSOLAR® FOR BACK CONTACT SOLAR CELLS

ICOSOLAR® Properties:
• Direct contact to solar cell

Source: Solland Solar
10% higher power/m²
ICOSOLAR® FOR THIN FILM MODULES

ICOSOLAR® Properties:

• Absolut barrier against water vapour with aluminium
• WVTR (23°C/85%) between 0.2 and 1.6 for transparent ICOSOLAR®
ICOSOLAR® ENCAPSULANT

ICOSOLAR® Encapsulant: One Product- many possibilities

- Backsheet or Frontsheet combined with a layer of thermoplastic encapsulation material
- Improved damp heat and UV stability and less water absorption compared to EVA
- Optimization of production process due to shorter lamination time
- No EVA necessary (no formation of acetic acid that might cause damage to the module)
- High Transparency and increased UV-stability
- Helps to reduce the effects of potential induced degradation (PID)
FRONTSHEET - BARRIER MATERIAL
FUTURE ASPECTS WITH FLEXIBLE DEVICES

- Renewable energy
  - Low cost and light weight solar cell

- Low CO₂ Emission
  - Low BOS costs
  - 1kWh solar power avoids 679g CO₂

- Global
  - ~1.4 billion people are without energy
MARKET WATCH

By 2022...

$380 million market for barriers for inorganic PV

Corresponds to 12 million m²

32% of total electronic market will be flexible

Source: IDTechEx Barrier Films for flexible Electronics 2012-2022

By 2020...

Global market forecast for organic devices

OPV, OLED, e-paper

48% of total organic electronic market will be flexible

## WHY NOT GLASS?

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
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<tr>
<td>+ cheap</td>
<td>- very heavy</td>
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<td>+ waterproof</td>
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<td>+ long shelf life</td>
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**ADVANTAGES:**
- cheap
- waterproof
- long shelf life

**DISADVANTAGES:**
- very heavy
- rigid
- fragile
- processability

With **Back- and Frontsheet** lower BOS are possible by cheaper transport cost, less installation time and no need for metal racks.
MAIN DRIVERS FOR FLEXIBLE FRONTSHEET

- Lifetime up to 20 years
- Thin and light weight
- Barrier against water vapour and oxygen
- r2r processability
- Integrable into portable devices
- Special performance e.g. anti-reflection layers
BARRIER PROPERTIES

Source: Fraunhofer ISC
DEFINITION WVTR

Definition WVTR (water vapour transmission rate) of $100$ to $10^{-6}\text{ g/m}^2\text{ d}$:

Amount of water vapour that permits through a polymer film in the size of a soccer field per month!
HOW TO MEASURE THE WVTR?

- Coulometric method (Keidel)
  - Mocon: WVTR: $5 \times 10^{-4}$ g/m² d
  - OTR: $5 \times 10^{-3}$ cc/m² d
  - time: ~ 2 weeks

- Calcium test
  - $2Ca + O_2 + H_2O \rightarrow Ca(OH)_2 + CaO$ + H₂O
  - reflective
  - conductive
  - transparent
  - insulating
  - measuring range: $10^{-6}$ g/m² d
  - time: dependent on barrier performance

- HTO test (Tritium test)
  - radioactive!
  - measuring range: $10^{-7}$ g/m² d
  - time: 30-45 Tage (22° C /100%)
**Transparent Barrier Frontsheet - Specification**

- WVTR $<10^{-4}$ g/m$^2$ d for CIGS
- >85% Transmission in the visible range
- Good stability under accelerated test conditions
- Good UV stability
- Low thickness, good adhesion to cell material
- Width: 2100 mm

**Components:** Polymer-MeOx, Organic Hybrid Polymers, Adhesion layers, anti-weathering layer,...
BARRIER MATERIALS - PET/MEOX SUBSTRATES

Measurements of various PET/MeOx substrates:
Substrates 1-5: PET/SiOx
Substrates 6-9: PET/AlOx
**BARRIER MATERIALS - ELECTRON MICROSCOPY**

**WVTR:** 0.017 g/ m² d  
@ 23°C / 85% r.h.

**WVTR:** 0.2 g/ m² d  
@ 23°C / 85% r.h.

*SEM 5 kx*

*TEM 67 kx*
# BARRIER MATERIALS - MEOX LAYERS

<table>
<thead>
<tr>
<th>MeOx layers</th>
<th>WVTR [g/m² d]</th>
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<tbody>
<tr>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>8</td>
<td>0.03</td>
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![Diagram of barrier materials with MeOx layers and WVTR values](image)

![SEM image of barrier layers](image)
BARRIER MATERIAL - ORGANIC HYBRID POLYMER

Tortuous Path:

BARRIER MATERIAL - MULTILAYER STACK

Below MOCON detection limit

Multilayer stack measured with different methods
**BARRIER MATERIAL - MULTILAYER STACK**

**Damp Heat Test (DHT)**

- **85°C / 85% rh**

Mocon detection limit

\(<5 \times 10^{-4} \text{ g/m}^2 \text{ d}\)

Transmission > 85% for transparent frontsheets in visible range
CONCLUSION

- Non-transparent materials for crystalline and thin film applications are available in different color and thickness
- Backsheets with copper for back-contact solar cells are available
- Materials with encapsulant layer are available
- Research on Transparent Barrier Frontsheets shows good results
NanoMend aims to pioneer the research & development of in-line, micro & nano-scale defect detection and correction systems on thin-films, which will transform the performance of a range of products including thin-film photovoltaics and fiber-based packaging.

- €7.25million grant funded, 4 year long FP7 project from Jan 2012
- 14 European Partners from Industry and academia
- The Project is being led by the University of Huddersfield

The NanoMend project has received funding from the EC Seventh Framework Programme (FP7/2007-2013) UNDER Grant Agreement No. 280581
R2R-CIGS aims to develop cost effective processes and technologies for the roll-to-roll production of thin film *flexible* CIGS solar modules in high volumes.

- European collaborative project
- Started in April 2012
- Duration 42 months
- info@r2r-cigs.com
AKNOWLEDGEMENT

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THANK YOU FOR YOUR ATTENTION!

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1st in backsheets.