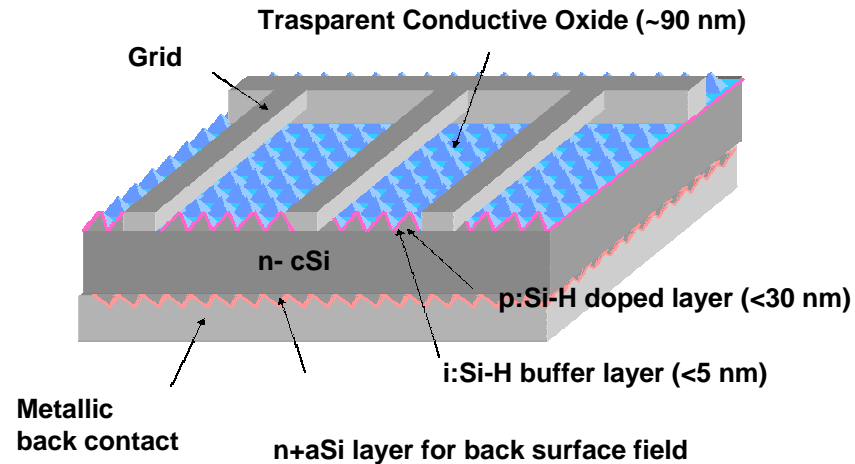


EUROHIT

EUROPEAN CONSORTIUM ON SILICON-HETEROJUNCTION PHOTOVOLTAICS



J. Cárabe. CIEMAT
F. Roca. ENEA Portici
J. Andreu. Univ. Barcelona

Ciemat



UNIVERSITAT DE BARCELONA



ENEA

1. INTRODUCTION

2. SHJ CELLS IN THE WORLD AND IN EUROPE

3. PROPOSAL FOR AN IP ON SILICON-HETEROJUNCTION PV: EUROHIT

Ciemat



UNIVERSITAT DE BARCELONA



ENEA

1. INTRODUCTION

2. SHJ CELLS IN THE WORLD AND IN EUROPE

3. PROPOSAL FOR AN IP ON SILICON-HETEROJUNCTION PV: EUROHIT

Ciemat



UNIVERSITAT DE BARCELONA



ENEA

Silicon dominates the PV market (~100%)

Wafer technology

- To lower costs (at the expense of crystallinity and thickness)
- To guarantee feedstock
- To minimise material waste

Thin-film technology

- Better charge transport (higher crystallinity and thickness)
- Better stability
- Higher growth rate

- 
- Medium crystallinity
 - Medium thickness ($\sim 10^1 \mu\text{m}$)
 - High fabrication throughput

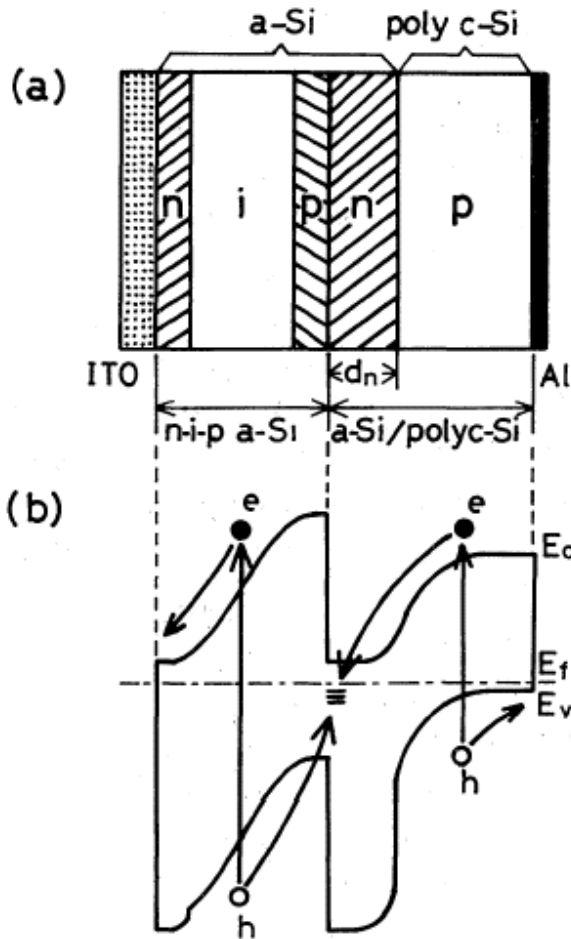
Silicon-Heterojunction Technology embodies the best of two worlds

Ciemat

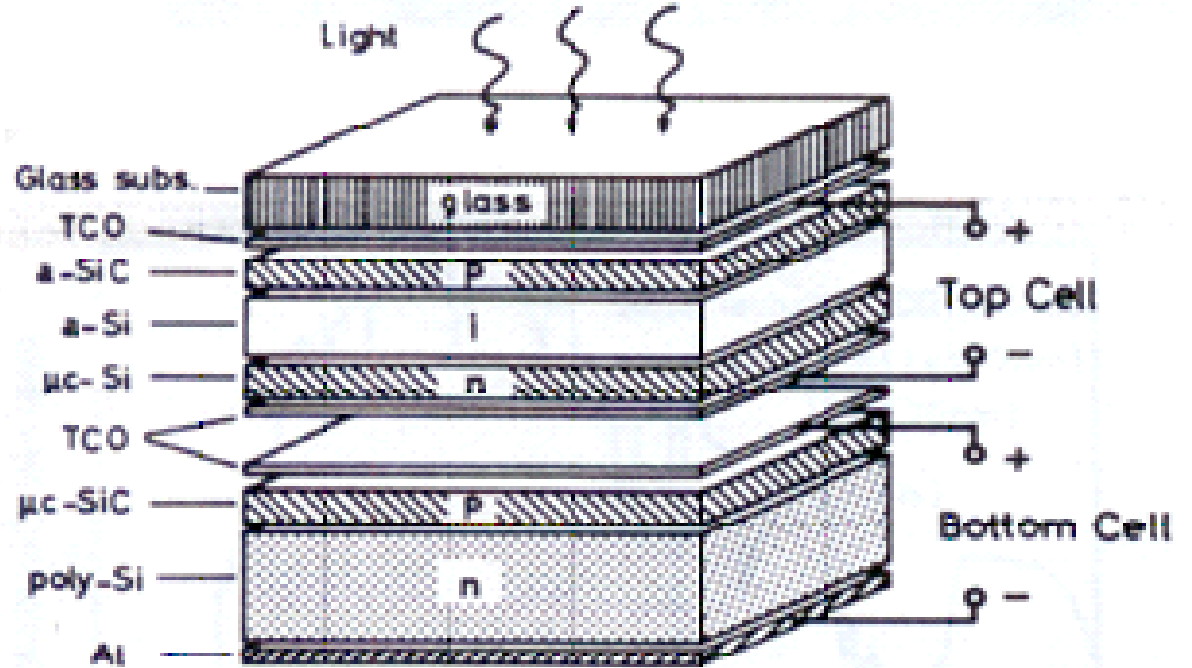


ENEA

Faculty of Engineering Science- Osaka (prof. Hamakawa)



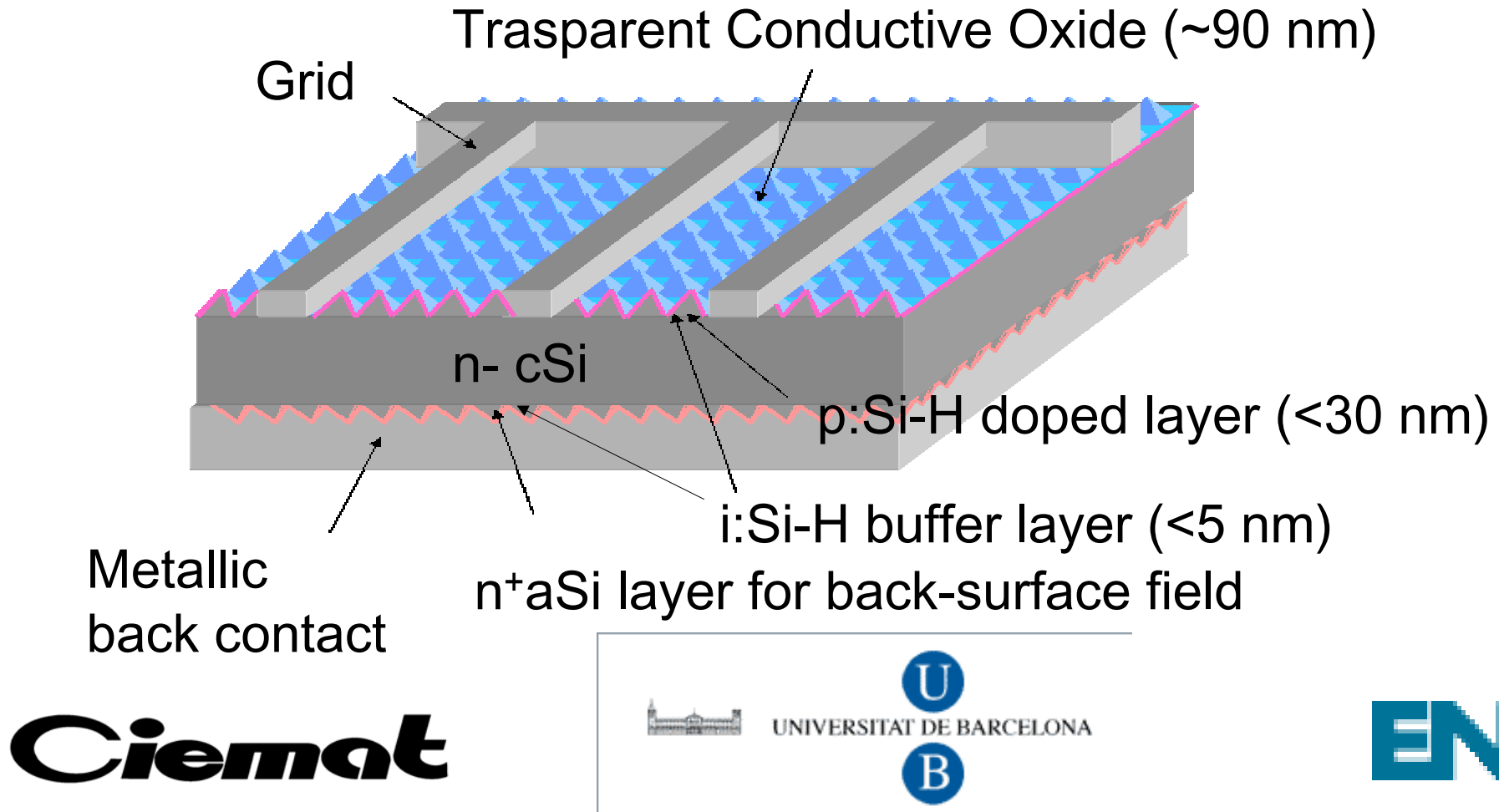
4T- "Honeymoon solar cells" (1991) – 21% eff.



G.A.Hirota, H. Okamoto and Y.Hamakawa IEEE Trans.ED Letters, 12 (1991) p.562

SHJ Solar cell: basic structure

One (two) thin-film-silicon layer(s) grown through Plasma-Enhanced Chemical Vapour deposition (RF-PECVD, VHF-PECVD; ECR-CVD) or HW-CVD



SHJ Solar cell: advantages

- **Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential**
- The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential
- Passivation of bulk material and wafer surface. Excellent back-surface field
- High efficiency ($\sim 21.0\%$) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)
- Junction depth easily and accurately controlled ($\sim 1\text{nm}$ - up to 100 nm or more). Suitable for medium-thickness absorbers
- Large gap emitter $1,6\text{ eV}$ - $2,3\text{ eV}$ to enhance the response in the blue area of solar spectra (window effect).
- Opportunities for Tandem structures

Ciemat



ENEA

SHJ Solar cell: advantages

- Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential
- **The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential**
- Passivation of bulk material and wafer surface. Excellent back-surface field
- High efficiency ($\sim 21.0\%$) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)
- Junction depth easily and accurately controlled ($\sim 1\text{nm}$ - up to 100 nm or more). Suitable for medium-thickness absorbers
- Large gap emitter $1,6\text{ eV}$ - $2,3\text{ eV}$ to enhance the response in the blue area of solar spectra (window effect).
- Opportunities for Tandem structures

Ciemat



ENEA

SHJ Solar cell: advantages

- Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential
- The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential
- **Passivation of bulk material and wafer surface. Excellent back-surface field**
- High efficiency ($\sim 21.0\%$) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)
- Junction depth easily and accurately controlled ($\sim 1\text{nm}$ - up to 100 nm or more). Suitable for medium-thickness absorbers
- Large gap emitter $1,6\text{ eV}$ - $2,3\text{ eV}$ to enhance the response in the blue area of solar spectra (window effect).
- Opportunities for Tandem structures

Ciemat



ENEA

SHJ Solar cell: advantages

- Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential
- The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential
- Passivation of bulk material and wafer surface. Excellent back-surface field
- **High efficiency (~21.0%) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)**
- Junction depth easily and accurately controlled (~1nm- up to 100 nm or more). Suitable for medium-thickness absorbers
- Large gap emitter 1,6 eV-2,3 eV to enhance the response in the blue area of solar spectra (window effect).
- Opportunities for Tandem structures

Ciemat



ENEA

SHJ Solar cell: advantages

- Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential
- The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential
- Passivation of bulk material and wafer surface. Excellent back-surface field
- High efficiency ($\sim 21.0\%$) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)
- **Junction depth easily and accurately controlled ($\sim 1\text{nm}$ - up to 100 nm or more). Suitable for medium-thickness absorbers**
- Large gap emitter $1,6\text{ eV}$ - $2,3\text{ eV}$ to enhance the response in the blue area of solar spectra (window effect).
- Opportunities for Tandem structures

Ciemat



ENEA

SHJ Solar cell: advantages

- Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential
- The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential
- Passivation of bulk material and wafer surface. Excellent back-surface field
- High efficiency ($\sim 21.0\%$) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)
- Junction depth easily and accurately controlled ($\sim 1\text{ nm}$ - up to 100 nm or more). Suitable for medium-thickness absorbers
- **Large-gap emitter 1,6 eV-2,3 eV to enhance the response in the blue area of solar spectra (window effect).**
- Opportunities for Tandem structures

Ciemat



ENEA

SHJ Solar cell: advantages

- Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential
- The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential
- Passivation of bulk material and wafer surface. Excellent back-surface field
- High efficiency ($\sim 21.0\%$) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)
- Junction depth easily and accurately controlled ($\sim 1\text{ nm}$ - up to 100 nm or more). Suitable for medium-thickness absorbers
- Large-gap emitter $1,6\text{ eV}$ - $2,3\text{ eV}$ to enhance the response in the blue area of solar spectra (window effect).
- **Opportunities for Tandem structures**

Ciemat



ENEA

SHJ Solar cell: advantages

- Simple structure. Easy to automate. Simple fabrication process. Very high cost-reduction potential
- The low-temperature ($\leq 250^{\circ}\text{C}$) process prevents carrier-lifetime degradation. Additional cost-reduction potential
- Passivation of bulk material and wafer surface. Excellent back-surface field
- High efficiency ($\sim 21.0\%$) and photostability. Superior performance at realistic working temperatures ($\geq 40^{\circ}\text{C}$)
- Junction depth easily and accurately controlled ($\sim 1\text{ nm}$ - up to 100 nm or more). Suitable for medium-thickness absorbers
- Large-gap emitter $1,6\text{ eV}$ - $2,3\text{ eV}$ to enhance the response in the blue area of solar spectra (window effect).
- Opportunities for Tandem structures

Ciemat



ENEA

1. INTRODUCTION

2. SHJ CELLS IN THE WORLD AND IN EUROPE

3. PROPOSAL FOR AN IP ON SILICON-HETEROJUNCTION PV: EUROHIT

Ciemat

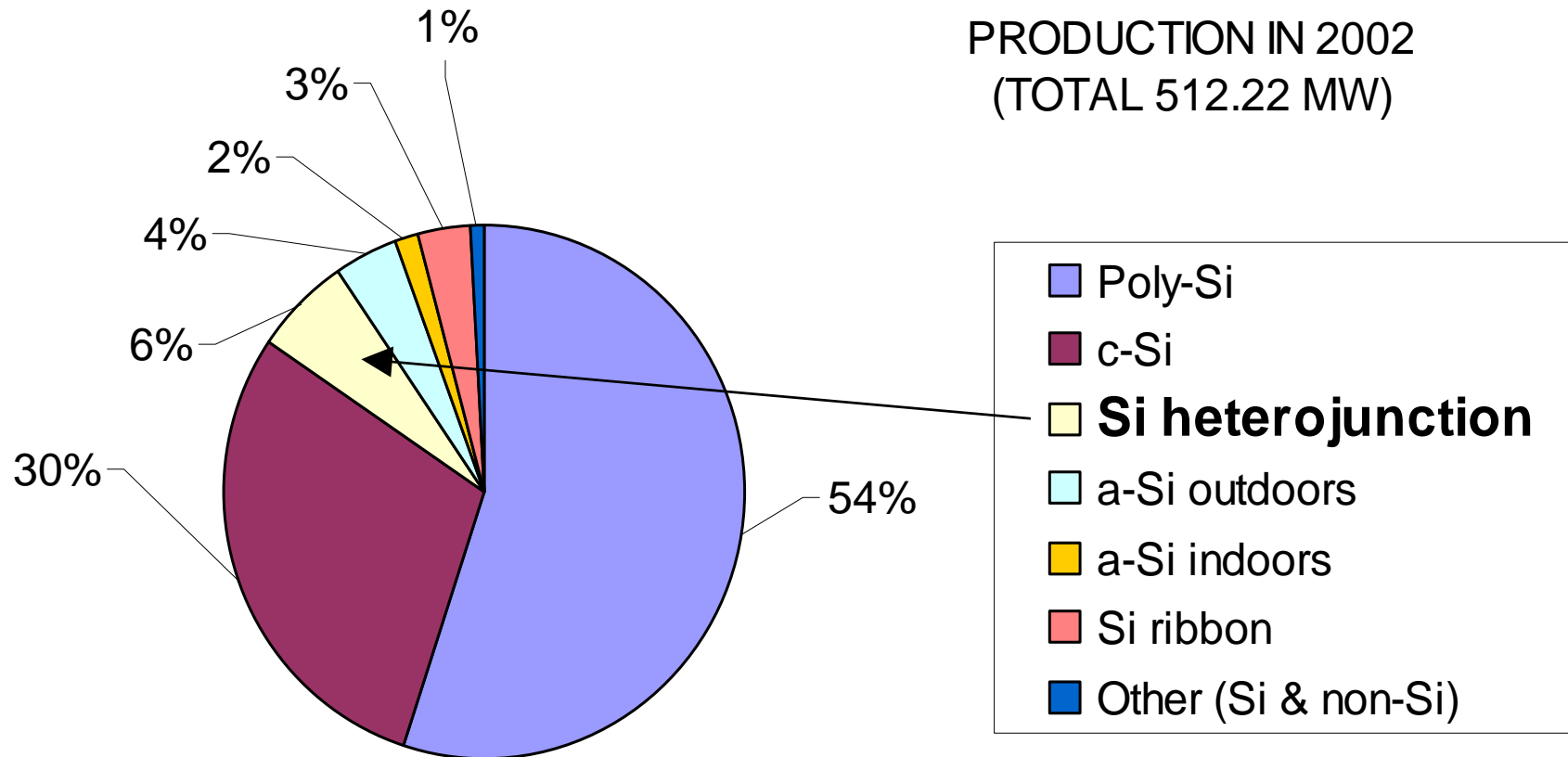


UNIVERSITAT DE BARCELONA



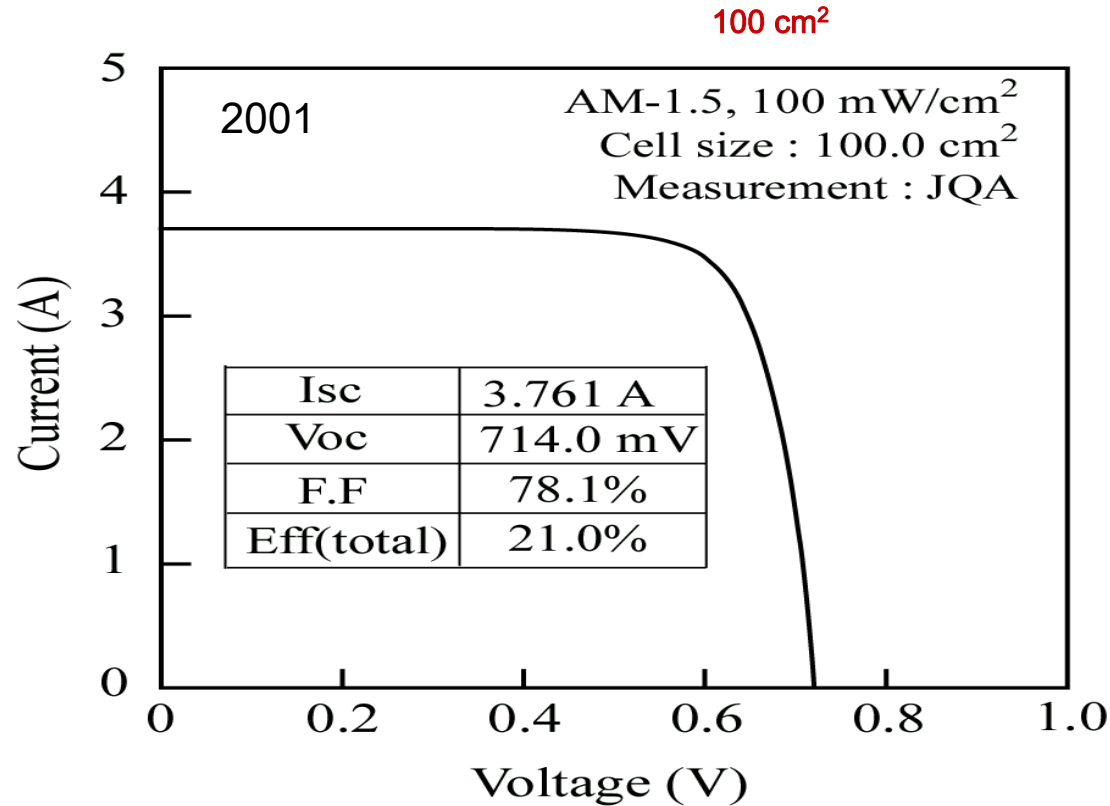
ENEA

PRODUCTION IN 2002 (TOTAL 512.22 MW)



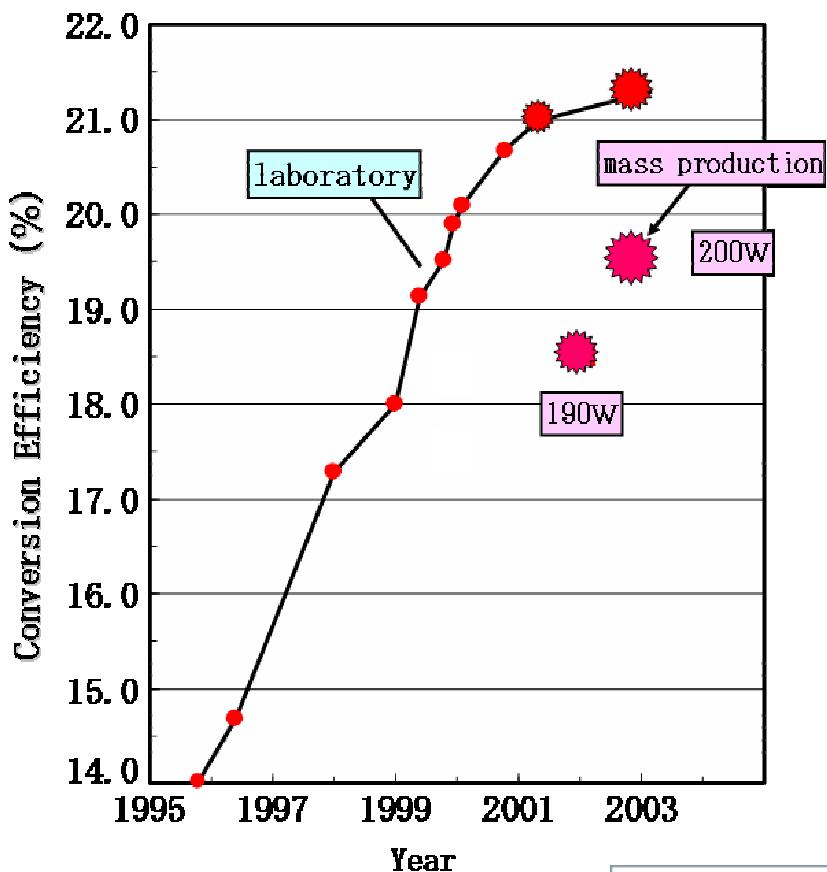
PV News 21/4, April (2002)

Sanyo 1992-2003



- Cell record efficiency: 21% (100 cm²)
- Commercial modules 17%
- 6% of the PV market in about 10 years

Evolution of Sanyo ACJ-HIT™ solar cells efficiency on area of typical interest for commercial applications (~100 cm²) *(Courtesy of Sanyo)*



30 MW

(~ 5.9% of 2002 world cell/module production)

PV NEWS.- March 2003,
Vo.22 /N°3 Editor: Paul
D:Maycock; 4539 Old Alburn
Road Warrenton, VA 20187
USA

Ciemat

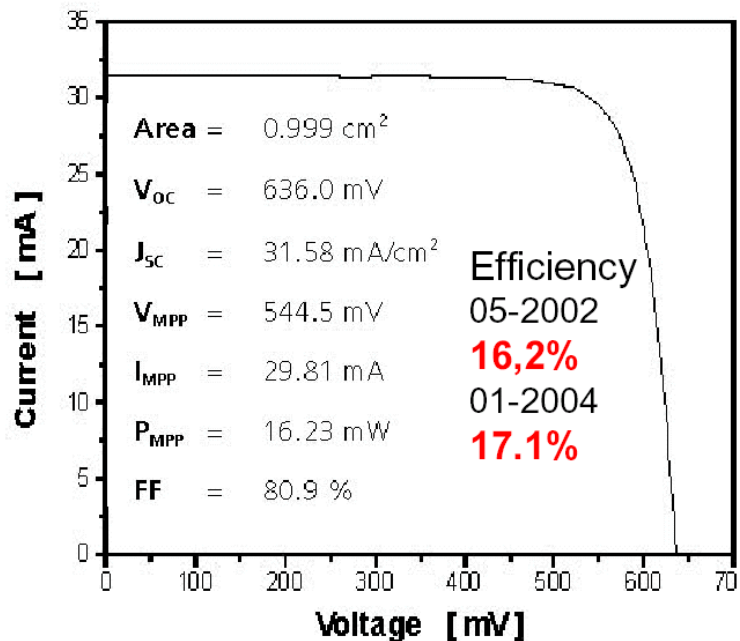


UNIVERSITAT DE BARCELONA



Best conversion efficiencies in Europe

FZ (100) p cSi back p-diffused

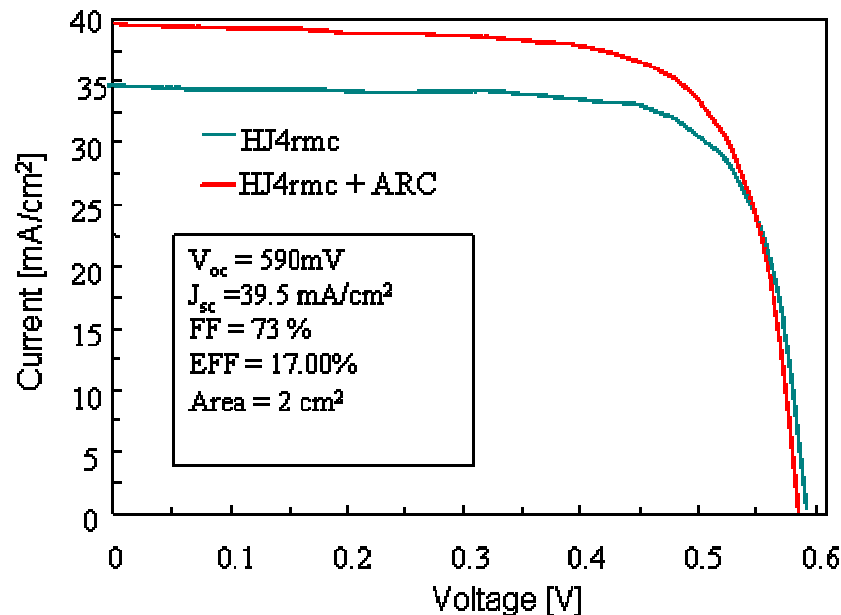


HMI, Uni Hagen

1.M. Scherff, A. Froitzheim, A. Uljaschin, M. Schmidt, W. Fuhs, W.R. Fahrner; Proc. PV in Europe Conf., Rome, Italy, Oct.2002,123-126

Ciemat

CZ (100) p cSi back Al-screen printing+firing



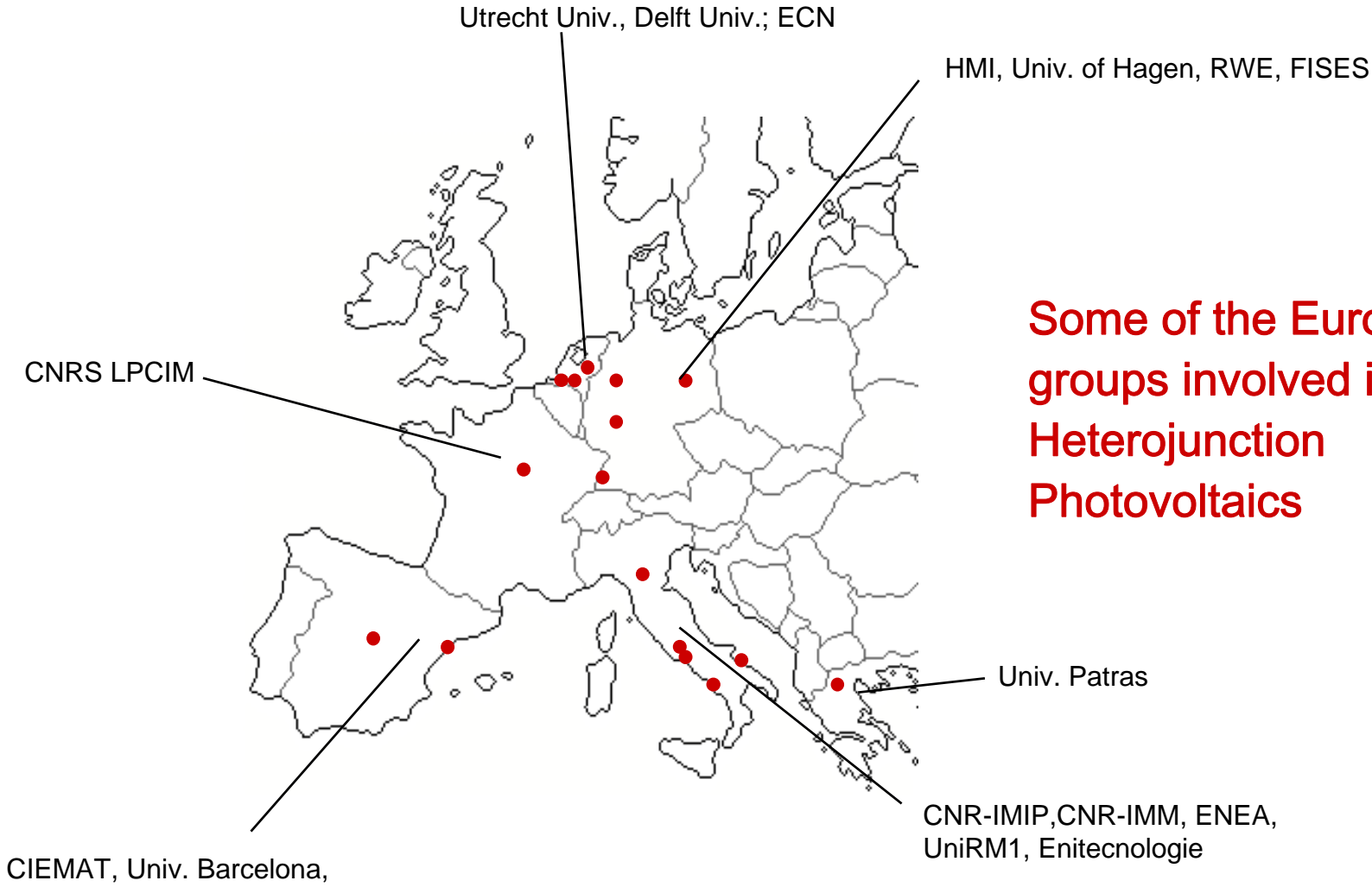
ENEA, UniRM1

1.M. Tucci, G.de Cesare J. Non-Cryst. Solids 2004 (in print).



ENEA

Some of the European groups involved in Silicon-Heterojunction Photovoltaics



1. INTRODUCTION

2. SHJ CELLS IN THE WORLD AND IN
EUROPE

3. PROPOSAL FOR AN IP ON SILICON-
HETEROJUNCTION PV: EUROHIT

Ciemat



UNIVERSITAT DE BARCELONA



ENEA

EUROHIT MAIN FEATURES

- Integrated Project
- About 15 groups all over Europe
 - Cell manufacturers
 - Silicon manufacturers
 - Deposition-equipment manufacturers
 - Universities
 - RTD centres
- 5-year time span

Ciemat



ENEA

EUROHIT SUBPROJECTS

- **SP1: ABSORBERS (WAFERS, RIBBONS...)**
- **SP2: EMITTERS**
- **SP3: INTERFACES**
- **SP4: CHARACTERISATION AND MODELLING**
- **SP5: CONTACTS**
- **SP6: ENVIRONMENTAL AND MARKET ASSESSMENT**

Ciemat



ENEA

For additional information please write to

Julio Cárabe – CIEMAT (julio.carabe@ciemat.es)

Francesco Roca – ENEA (roca@portici.enea.it)

Ciemat



ENEA