Large Area Wafer Workshop - Are bigger wafers better?

A general overview: Large versus Thin?

Anis Jouini – CEA/INES
For hardware ...

Premium PV Cells and modules | Process & equipment | X-IPV | Power electronics | PV plants Architectures

& software developments

Grid integration | Diagnosis & Data | Energy management systems | Storage | Smart grids & Smart cities

~150 Industrial partners
INES – New website

Nos champs d'applications

- Photovoltaïque haut rendement
- Photovoltaïque intégré X-IPV
- Photovoltaïque et stockage au service du mix énergétique
- Du bâtiment à la smart-city
- Les Smart-grids multi-énergies
- Économie et environnement

Research & Education for Solar Energy

Anis Jouini 2021, P-4/12
Transformation
Renewables new era

GREEN majors

« Italy’s Enel programs €160 billion investment in renewable energies by 2030 »

OIL majors

« €75 billion € by 2025 and €150 billion by 2030 »

Total « New promising strategy towards renewables »

Source: FactSet
PV Power Plants
BIG, BIGGER, BIGGEST
xMW, x10MW, x100 MW, xGW

2021 Production capacity
+250 GW

New international HJT Eco-system

2021

New PV modules
For the new challenges
Power, Price, Quality, Eco-design…
1. Growth Technology
   1. Cz, CCz (Market leading with 190 to 194 GW in 2021)
   2. Cast (~Very small market Share 6 to 10 GW in 2021)

2. Doping
   1. P-type B, Ga (190 to 193 GW market share in 2021)
   2. N-type P, ... (7 to 10 GW market share in 2021)

3. Growth Rate vs Quality: Oxygen, Metallic Impurities

4. Price depending on manufacturing

5. Recycling strategy towards productivity and lower C foot print processes
Wafer evolution

CEA INES 2006 - 2020

170 µm - $0.484

- M2 156.75 Pseudo Square Mono-cell
- M4 161.70 Pseudo square 211 Diagonal Line
- M4+ 161.70 Full square Mono-cell

CEA INES 2021+

175 µm - $0.606

- M10 182.0 Full square Mono-cell
- M12 210.0 Full square Mono-cell

Less cabling = Balance of System reduction

Upgraded or Old New equipment

211mm

223mm

257mm

297mm

223mm

Longi price on February 26, 2021
Challenges raised by larger wafers: Large vs Thin

M12 cell produced @ INES in 2005

300 mm Ø ingot (M12 compatible)

M10 & G12 wafers raise important scientific & technological challenges in addition to their potential

Wafers handling / Automation
Wafers sticking in wet carriers
Process heterogeneities during high T processing
Heterojunction Cell Technology (horizontal deposition processes)

Technology roadmap

- **25% efficiency**: multibusbars total area on M2 wafers
- **Larger wafers** (M6, M10, M12) and **cut cells**
- **Cost reduction**: Silver paste & ITO, higher throughput with new generation equipments

Example for metallization:

- 250 mg silver paste for 4 busbars cells
- 150 mg silver paste for 6 busbars cells

Silver reduction of 40%
In ONE photo?
Smart PV integration

• From +5W/yr to +50W in one move
• Interconnection is becoming a hot subject
• **No standard**: Adapted products
Moore and Beyond

1. Cell $\eta$ Reaching the limit After +0.6%/yr progress

2. Module power increase
   Shingling, gapless, 1/x cut cells, Size

3. Cell $\eta$ Increase
   New cell concepts (tandem)
CEA-INES France – PV everywhere

Recyclability
Aesthetic
Performance
Pressure
Corrosion
Environment
Radiation
Reliability
New Functionalities
Eco-conception
Integrated PV
Low Cost

THANK YOU