

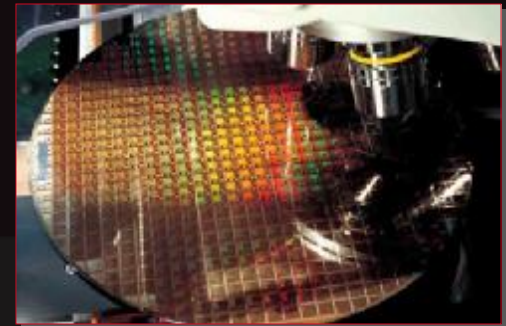
tsmc solar

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TSMC – Highlights

- Founded in 1987
- \$100 billion market capitalization
- \$17 billion global annual sales
- World's largest dedicated semiconductor foundry with >50% market share
- Semiconductor technology leader, with 14,500+ patents
- 2nd largest semiconductor manufacturing capacity
- Fabs in Taiwan, USA, Singapore & China
- 34,000 employees worldwide



TSMC Supports Your Everyday Life



TSMC Solar – our values

Our core values are:

- Integrity
- Commitment
- Innovation
- Customer-focused thinking

If we promise it, we do it.

TSMC Solar's identity is rooted in these values, and they are the basis for long-term and successful customer relationships.



How do TSMC CIGS modules work?

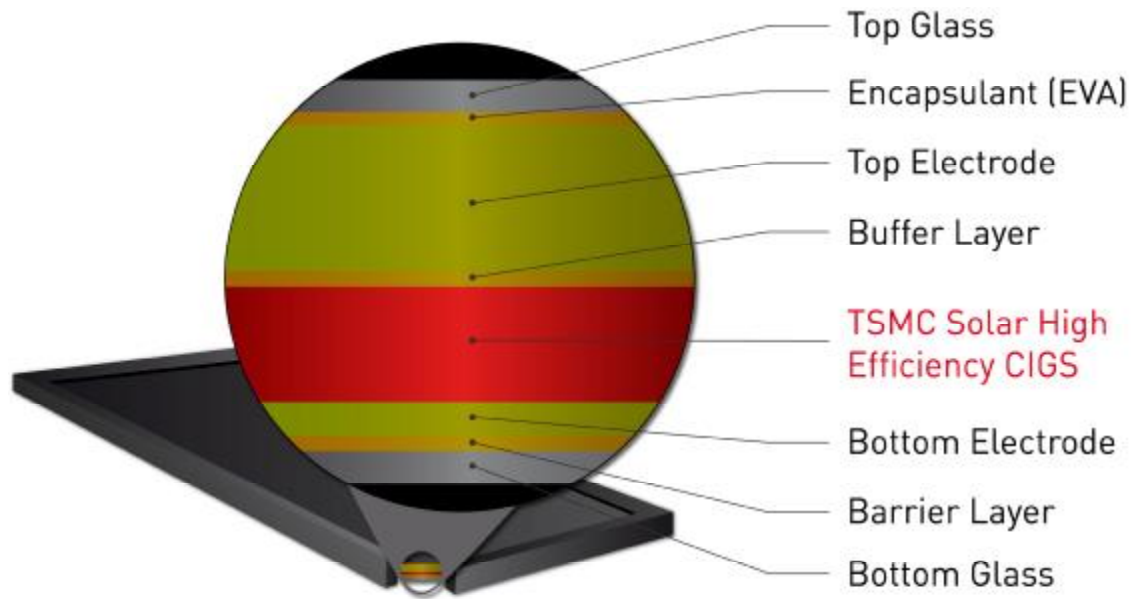
- The central concept common to all thin-film modules is the use of a single, very thin deposited layer of semiconductor material in order to avoid the high costs of the raw materials and energy required to produce high-purity silicon wafers.
- A variety of semiconductor materials are used to make thin-film modules – those in commercial production include: amorphous silicon (a-Si), micromorph silicon (mSi), cadmium telluride (CdTe) and compounds made of copper, indium, gallium and selenium (CIGS).

How do TSMC CIGS modules work?

- Unlike typical crystalline silicon module production, producing thin-film modules involves depositing thin layers of semiconductor material on a surface made of glass, metal or plastic at 250–500° C (according to the type of material), whereby only about a tenth of the semiconductor material used in silicon wafers is required and significantly less energy needed.



TSMC Solar – CIGS module produced on most recent tool generation – delivering high quality modules



TSMC CIGS production process



- 1 GLASS FEEDSTOCK**
Glass substrate supports CIGS cells



- 2 BOTTOM ELECTRODE**
 - ▶ Molybdenum coating applied to glass
 - ▶ P1 laser scribing patterning on electrode



- 3 CIGS DEPOSITION**
 - ▶ High quality absorber layer achieved through proprietary deposition process
 - ▶ Buffer layer: formation of n-type semiconductor atop the absorber
 - ▶ P2 mechanical scribing patterning on absorber and buffer layers



- 4 TOP ELECTRODE**
 - ▶ Formed by doped Zinc Oxide
 - ▶ P3 mechanical scribing patterning on top electrode



- 5 FRAMING**
 - ▶ Lamination of monolithic glass on glass module
 - ▶ All black aluminium frame for enhanced aesthetics



- 6 TSMC SOLAR CIGS SOLAR PANEL**
 - ▶ Flash testing
 - ▶ Packaging for shipment

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TSMC Solar R&D Center and Fab in Taiwan



Green Building
Certification in
Progress



LEED NC Gold

Manufacturing excellence delivers high-performance

- Solar modules are almost unique among technology products, in that their life cycle is 25 years or longer. Quality and reliability of your solar modules is of the utmost importance.
- Our parent company **TSMC** is one of the leading high-technology companies in the world.
- **TSMC's** success has rested on three pillars: Advanced Technology, Manufacturing Excellence, and Customer Partnerships based on building close and trusting relationships.



Manufacturing excellence delivers high-performance

- Automation is critical to manufacturing productivity and quality.
- Our Automated Materials Handling System, uses multiple types of advanced robots together with customized panel and cassette handling systems throughout the factory.



TSMC Solar's quality standards

- TSMC Solar carries this heritage forward.
- Quality standards are upheld in all aspects of the production process – from the high-purity raw materials to the highly proprietary manufacturing process with comprehensive quality controls right through to delivery of finished modules to our customers.



TSMC Solar – CIGS Series 145 W / 150 W / 155 W

Features

- Advanced proprietary CIGS thin-film technology
- Plus sorting at +5W to -0W
- Low temperature coefficient provides yield benefits
- Aesthetically appealing all-black appearance
- Framed module designed for easy use with industry-standard mounting systems
- Etched, unchangeable serial numbers for full traceability of each module



TSMC Solar – CIGS Series 145 W / 150 W / 155 W

Quality and Safety

- UL and IEC (TUV SUD) certified
- Rated for snow and wind loads up to 2.400 Pa
- Free of Potential Induced Degradation (PID) effects
- Salt mist and blowing sand test certifications
- Manufactured at an ISO 9001:2008, ISO 14001 and OHSAS 18001 certified facility



TSMC – CIGS Series 145 W / 150 W / 155 W

Warranty

- Product warranty:
10 years for material and workmanship
- Power and output warranty: 90 % at 10 years
and 80 % at 25 years of minimum rated power output



TSMC Solar – Reasons for choosing our products

- All-black aesthetically appealing appearance
- 14%+ module efficiency
- Additional energy yield through excellent temperature coefficient
- Superior low-light behavior
- Superior shading tolerance
- PID Free
- No positive grounding required
- Stock warehoused in Europe

Aesthetically appealing all-black module



Residential



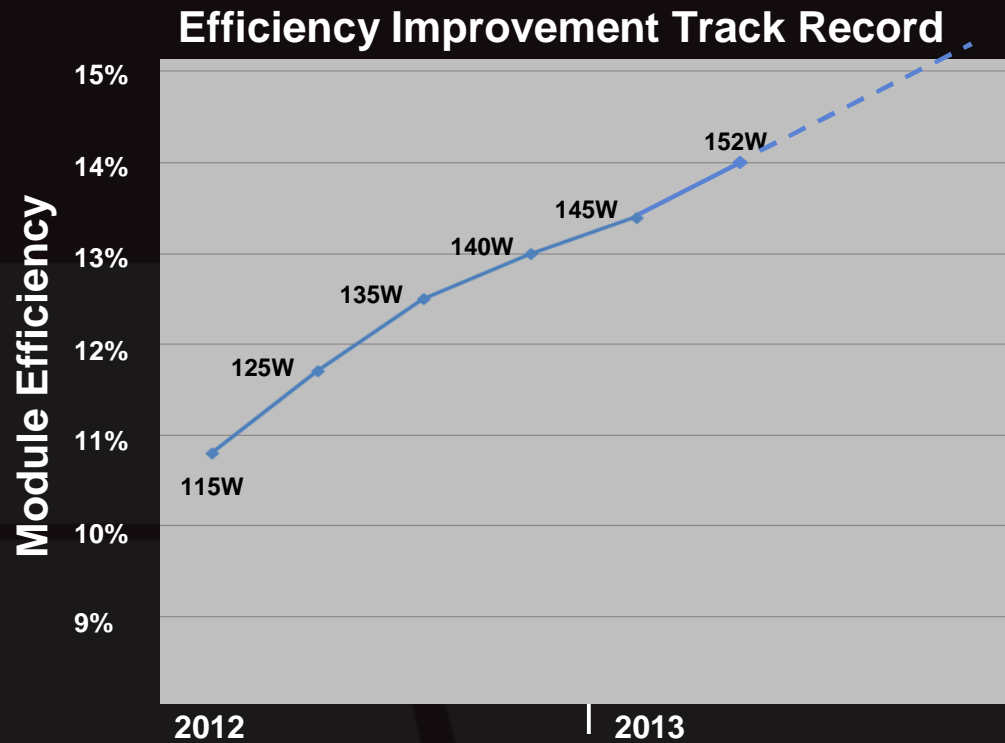
Commercial - Roof top



Utility Scale – Ground Mount

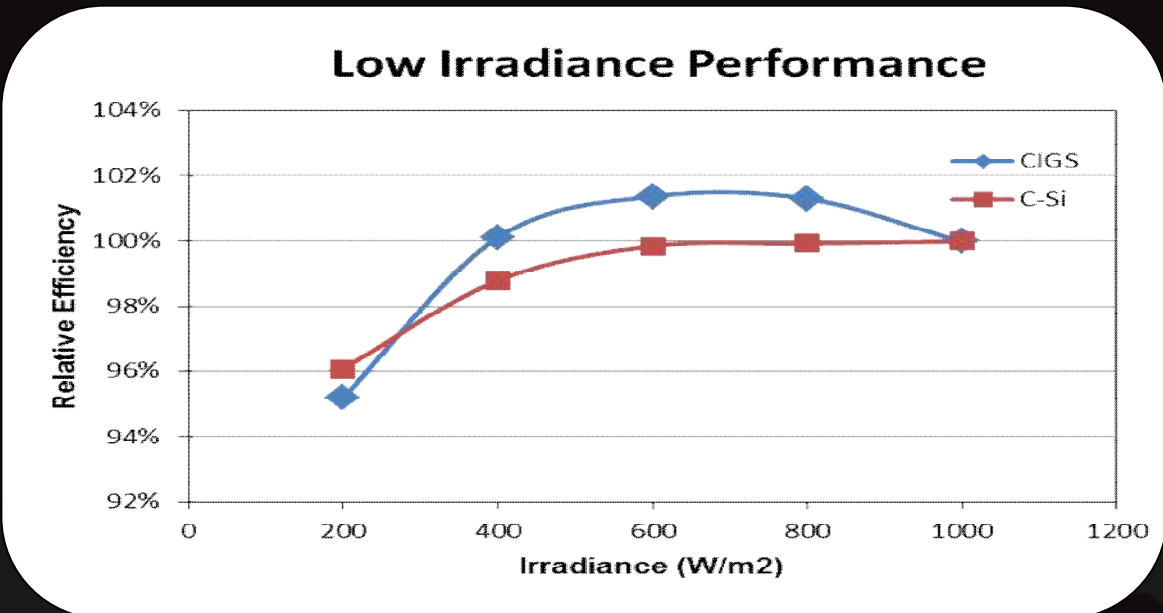
Product evolution drives efficiency improvements further

- TSMC Solar aims for highest module efficiency in CIGS technology
- Continuous product evolution drives name plate power further up
- World record hold (module efficiency of more than 15,7% from running production realised)



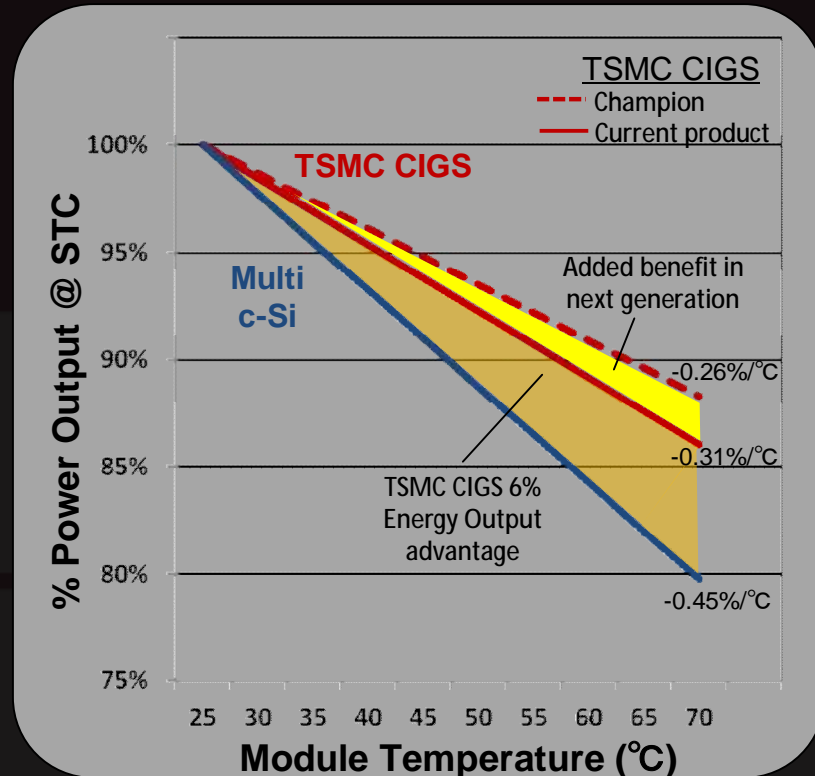
Superior Low-Light Performance

- Efficiency actually increases above datasheet levels in low-light conditions (400-1000 W/m²)
- Higher electricity production than other technologies with same power rating



Excellent Energy Yield at High Temperatures

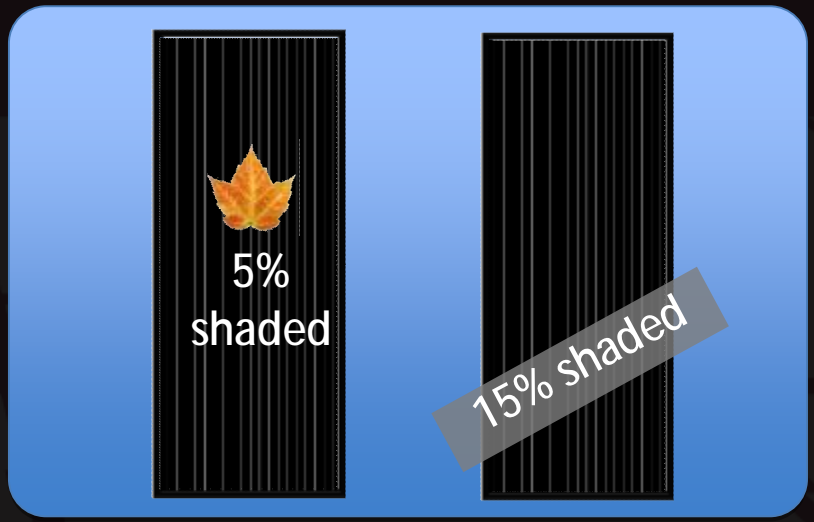
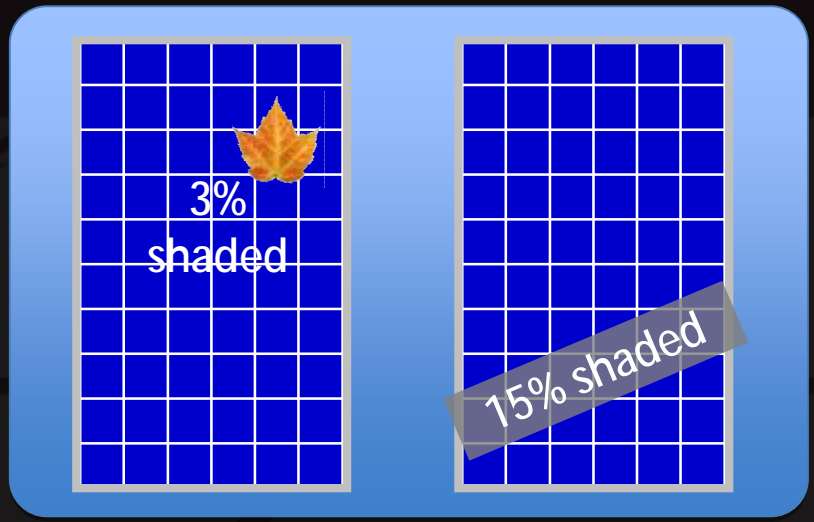
- As temperatures rise, all PV semiconductor technologies incur increasing losses in power output
- CIGS has less temperature-related power loss than crystalline modules due to a lower temperature coefficient
- Typical crystalline module temperature coefficient -0.45 to -0.50% per ° C
- TSMC CIGS temperature coefficient is -0.31% per ° C, with proven production champion already achieving -0.26%/° C



Superior Shading Tolerance of TSMC CIGS

C-Si: Small amounts of shading can cause **out of proportion power loss**

TS CIGS: Shading losses **proportional** to shaded area



66% power loss

100% power loss

5% power loss

15% power loss

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