

MANZ BACKGROUND INFO TO CIGS ORDER



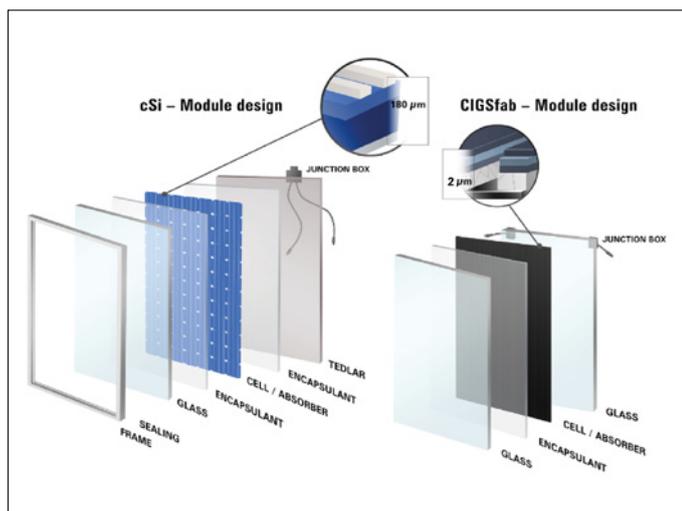
International Breakthrough for CIGS Thin-film Solar Technology by Manz!

» What does CIGS stand for? «

CIGS stands for the power generating semiconductor material consisting of copper, indium, gallium, and diselenide. This

semiconductor is evaporated as a very thin layer ("thin-film") on a glass panel during an innovative vacuum process.

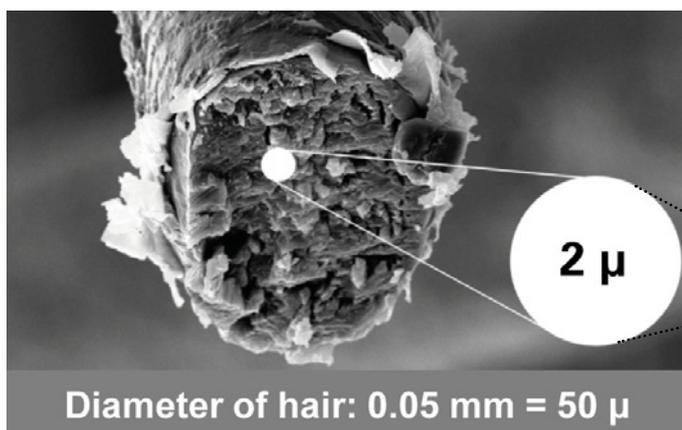
» What is the difference between the crystalline and the thin-film solar technology? «



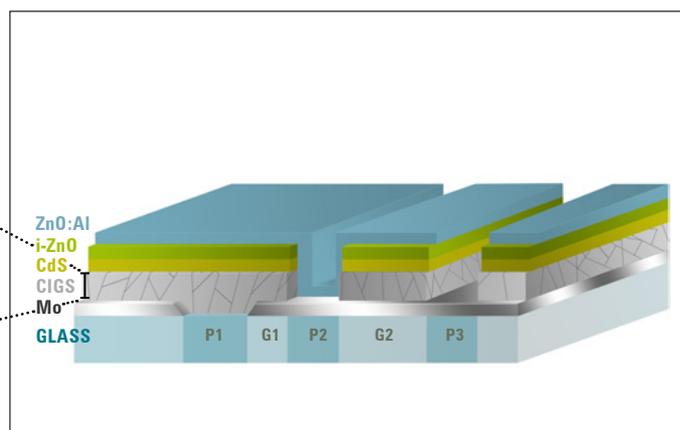
Schematic layout of a crystalline solar cell and a CIGS solar module

In a conventional crystalline solar module, a high number of single solar cells are soldered and mounted between a glass panel and a film. A crystalline solar cell is based on a silicon wafer which is sawn from a silicon block.

This wafer of high-purity silicon is up to 100 times thicker than the semiconductor layer CIGS of a thin-film module. This is evaporated directly in a single process step in a vacuum unit, onto a glass panel. The use of expensive semiconductor material is correspondingly higher in the case of crystalline technology. Moreover, in the case of thin-film technology, the direct application of the semiconductor on the glass substrate eliminates the labor-intensive and complex multi-stage process of raw silicon, wafer, cell and module production.

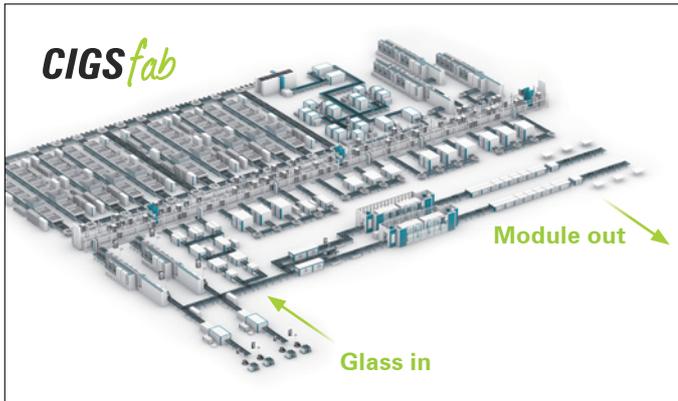


Diameter of hair in comparison to a CIGS semiconductor layer



CIGS semiconductor layers

» What is the Manz CIGSfab? «



Schematic layout of Manz' "Glass to Energy Process"

In the turnkey Manz CIGSfab a solar module is manufactured starting from a normal glass panel in a fully integrated production process. The complete production process is fully automated. Complex production steps, which are required, for example, for the production of a silicon wafer in crystalline technology, are not necessary. The production process is significantly shorter, the production costs are significantly lower. This has also a positive effect on the payback time of the energy used for the production of the module: while this is around two years for crystalline solar cells, it has been reduced to under nine months for CIGS modules.

» What contribution has Manz made so far for the development of the solar industry? «

Manz is a pioneer in the development and manufacture of high-tech production equipment for the solar industry. In the last three decades, the company has therefore contributed with its technology to the fact that photovoltaics is today a competitive form of energy generation and, in our opinion, will even be the cheapest form of energy generation in future.

- From 1990 development and production of machines for the manufacture of crystalline solar cells.
- From 2005 development and production of machines for the manufacture of thin-film solar modules.
 - Initially, we offered single machines in the field of laser scribing, automation and glass cleaning.
 - With the start of the cooperation with Würth Solar in 2010, we also offered a fully integrated, turnkey production line for CIGS thin-film solar modules, the Manz CIGSfab.

- After the complete takeover of the CIGS technology and the production line of Würth Solar in 2012, Manz, together with the exclusive research partner ZSW, focused on the further development of CIGS technology and thus on increasing the efficiency while reducing production costs. With various efficiency world records and drastic cost reductions renowned successes have been achieved in recent years in this area.

Manz has significantly influenced both crystalline solar technology and thin-film technology with its developments. **Based on many years of experience, Manz is convinced that the still dominant crystalline technology will no longer be able to compete with the rapid development of thin-film technology.** Thin-film technology has significant advantages in terms of further cost savings and increase in efficiency and offers far higher potential than the crystalline silicon solar technology which has nearly reached the end of its development.

Among thin-film technologies, CIGS is considered the technology with the greatest potential.

» Why is CIGS so superior to the crystalline technology? «

Material and production costs

- Significantly lower use of semiconductor material (up to 100 times less). This results in significantly lower costs and a significantly lower dependence on strong price fluctuations in the semiconductor material.
- Significantly shorter and fully automated production process with correspondingly lower production costs.

Efficiency

Already today, the efficiency of the Manz "champion module" is 16 % and at the level of multi-crystalline cells. The enormous potential is demonstrated by the 22.6 % efficiency world record on the laboratory cell format of the ZSW. The world record technology is now being transferred to the mass production processes of the Manz *CIGSfab*.

Costs per watt

Considering the costs per watt (the actual manufacturing costs of the solar modules) those of the CIGS technology are already today significantly lower than those of the crystalline technology. As a result of the planned scaling of the production capacities, they can be dramatically reduced again. The cost advantages, compared with today still dominating silicon solar technology, will even increase.

Costs of energy generation

The cost advantage of CIGS technology increases by considering the actually relevant costs of power generation, the costs per kilowatt hour. If a CIGS module and a crystalline silicon module with the same nominal power are installed next to each other, the CIGS module generates 10 to 15 % more power during the year. This is because of the physical properties of the CIGS modules: In weak light, so in the morning and evening hours as well as in the case of cloudiness or smog, they generate more energy than silicon modules.

Another great advantage during the summer months and especially in areas with higher temperatures is the better temperature coefficient. This feature of the CIGS semiconductor ensures that a CIGS module loses less power at high temperatures than a silicon module.

Expanded fields of application

CIGS modules can basically be used for the same applications as silicon solar modules. Due to their uniform black surface CIGS modules give a better aesthetic impression. This leads to an excellent suitability for use in building-integrated photovoltaics. Both roof-integrated CIGS modules as well as façade modules represent a visually appealing and, above all, energetically viable alternative to conventional building materials.



BIPV (building-integrated photovoltaics)

MANZ AG

Manz is a globally active high-tech equipment manufacturer and with an experience of more than 30 years pioneer in mechanical engineering for the solar industry.

With its *CIGSfab*, Manz is the world's only provider of a fully integrated, turnkey production line for manufacturing CIGS thin-film solar modules.

» Why isn't CIGS much more common today? «

This is due to the relatively complex and therefore difficult to handle production process. For many years, the efficiency of CIGS thin-film modules was also significantly lower than the one of silicon modules.

In both areas Manz has made significant progress over the last five years. With state-of-the-art technology by Manz, the CIGS semiconductor can now be deposited very efficiently and above all with high quality.

The gap between the efficiency of a CIGS and a multi-crystalline solar module is now only marginal as a result of the continuous further development of the CIGS technology.

Manz builds on 40 years of research in Baden-Württemberg. The exclusive access to the research results of ZSW, the world's leading research institute for CIGS technology, as well as its own expertise as a mechanical engineering company are the key to the success of the business model.

» What does the strategic cooperation of Manz with Shanghai Electric and Shenhua mean to CIGS technology? «

- The cooperation as well as the order from the two leading companies of the Chinese energy sector impressively demonstrate the high potential of the technology. The complex and expensive development work in Baden-Württemberg during the last four decades now pays off: The CIGS thin-film solar technology conquers the world market.
- Both Shanghai Electric and Shenhua have to shift their strategic focus in the energy sector towards renewable energies in order to be able to fulfill the environmental objectives of the Chinese government. CIGS is of crucial importance in the field of photovoltaics. The resulting seriousness and the planned development budgets will have a very positive effect on the further development of the technology.
- The collaboration with Shanghai Electric and Shenhua creates the world's largest and most effective research center for CIGS technology. The development of the technology is thereby substantially accelerated. The immense potential for further cost reductions and efficiency increases will be exploited even faster.
- Solar technology will experience a sustained growth momentum by the complement of the previously dominant crystalline technology with the more efficient and cost-effective CIGS thin-film technology.
- Solar power from CIGS thin-film solar modules in the near future will be the cheapest form of energy generation.

ZSW

The Centre for Solar Energy and Hydrogen Research Baden-Württemberg, ZSW is one of the leading institutes for applied research in the areas of photovoltaics, renewable fuels, battery technology, fuel cells and energy system

analysis. In the area of CIGS, the ZSW holds the world efficiency record with 22.6 %. Both Manz as an industrial partner of the ZSW and the newly founded &D joint venture have exclusive access to this technology.

» What does the strategic cooperation of Manz with Shanghai Electric and Shenhua as well as the bulk order mean to Manz? «

- Manz is going to commercialize trailblazing future-oriented technology together with two strategic partners in China. The acquisition of the Manz CIGS Technology GmbH by the R&D JV still has to be approved by the governmental authorities in China. This is common practice in China. The purchase orders will become effective as soon as the approval is granted. Manz assumes that this will happen within the next weeks.
- Biggest order in company history of Manz.
- Manz is now in a position to realize a profitable growth of the company on a financially strong basis. Manz is convinced that this first order of two prestigious companies of the energy sector will trigger corresponding impulses also in markets outside of China. The accelerated further development of the CIGS technology will also add further dynamism to the demand for the Manz CIGSfab.
- Manz is the only mechanical engineering company in the world to have the comprehensive technology portfolio and know-how to supply turnkey production lines for the production of CIGS solar modules.
- The contract, according to Manz, is only the first step in the cooperation. Especially in China, the world's largest energy consumer, Shanghai Electric and Shenhua dispose of an excellent market access and intend to build additional CIGSfabs with a total capacity of several GW. In the coming years, this will correspond to a turnover potential for Manz AG of several billion euros.
- In combination with the good prospects in the strategic business units Electronics and Energy Storage, Manz sees itself very well positioned for the future. The good order situation and high utilization of the company will also have a positive impact on the company's personnel growth at its locations.
- The research location at Schwäbisch Hall, **Manz CIGS Technology GmbH**, will also have very good prospects for the future. The location will in future be part of the R&D joint venture with Shanghai Electric and Shenhua and will continue to play a key role in the further development of the technology. A location and job guarantee has also been negotiated for the next five years.

SHANGHAI ELECTRIC GROUP

Shanghai Electric is anchor investor of Manz AG and one of the largest and most comprehensive equipment manufacturing conglomerates in China, possessing four main businesses with regard to high efficiency & clean

energy, new energy, industrial equipment, and modern services. The core business is still the construction of fossil power plants for coal and gas.

SHENHUA GROUP

The Shenhua Group Corporation Ltd. is the largest and most modern coal enterprise in China and the world's largest operator of coal mines. Shenhua operates its own comprehensive transport logistics for coal with its own railways and ships.

Shenhua is one of the largest energy producers in China. The conversion of the energy generation portfolio to renewable energies has already been initiated with massive investments in wind energy and has now been continued with the investment in solar energy.