J. v. G. technology GmbH

The DESERT company

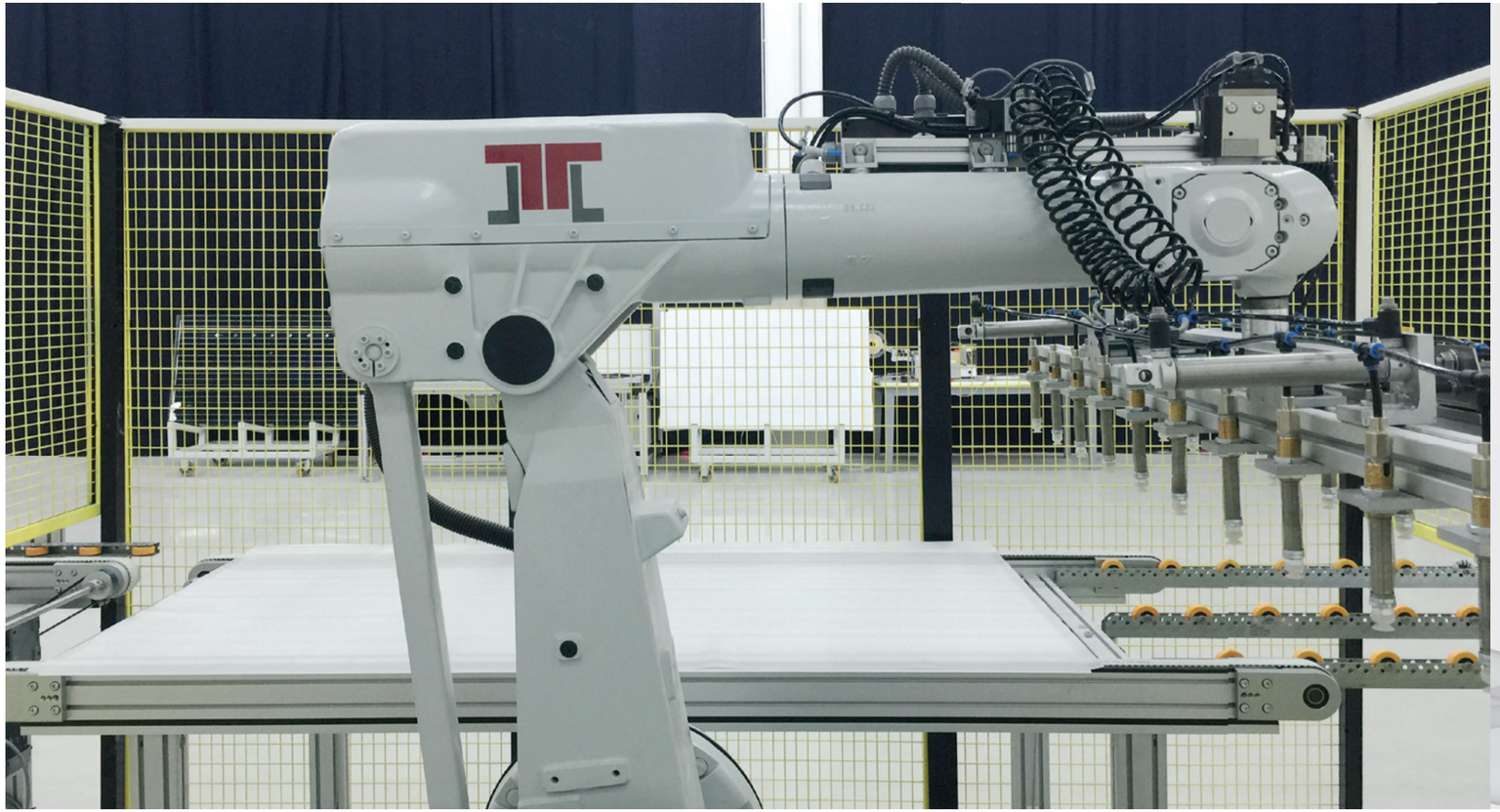
DESERT® Modules:
made for desert conditions

TROPIC® Modules:
made for extreme wet conditions

High-temperature Module: Process Technology

Desert is a patented technology of J.v.G. technology GmbH

Developed in cooperation with FRAUNHOFERCSP; Germany



Content

1 J.v.G. technology GmbH: The solar makers technology, competence and quality. From Europe and Turkey.

The experts of J.v.G. are pleased to provide you advice and support in all fields – from the design and planning right up to the construction of turnkey solar production systems.
Our service includes a wide spectrum from which you can compile the package of services that suits and meets your requirements. What does this include? For example TÜV certifications, training courses, transport, ramp-up service, DESERT®/TROPIC® process technologies, extended warranty periods, spare parts and much more. So that you are not confronted with any open issues...

As the leader in the industry, J.v.G. technology GmbH is an international player; large enterprises in the whole of Europe, America and Asia trust and rely on our expert knowledge.
Our company headquarters is situated in Freystadt, Hilpoltstein and Auerbach in Bavaria.

Meanwhile we have developed DESERT; ask for more information!

2 More Power: Your benefits with J.v.G.

You have access to new, path-breaking processes – both in the manufacturing process as well as in the module technology. J.v.G. has its own in-house research department and is the holder of numerous patents pertaining to the production process. Do not merely keep pace with the competition, but play an active role in developing the market!
An important milestone in this path is the HPTP technology of J.v.G. technology GmbH. It is the basis of the so-called Desert Modules™ (High-temperature modules).

2.1 DESERT®/TROPIC® general information

The application of PV modules in the extreme climates of the desert regions involves specific requirements concerning raliability issues due to high environmental stresses influencing all module components. Up to now, PV modules and certifications are optimized for the needs of the major PV markets of the past, being mainly situated in Europe before 2014.
To reach typical lifetimes of 20 to 25 years also for desert regions, the technical configuration and design of PV modules and components needs to be adapted to the specific environmental conditions. High stress levels have to be considered as challenges especially for the following environmental factors:

- High irradiation level, including UV
- High ambient temperature, also including high temperature changes
- Sand and dust: soiling and abrasion
- Relative humidity
- Mechanical loads (wind speed)

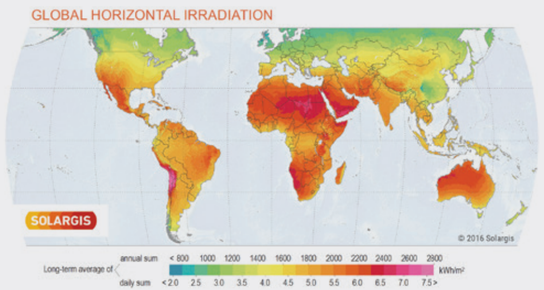
A desert module should be optimized to harness the great potential of the high irradiation levels in the solar-rich countries, reducing losses due to durability issues at the same time. By optimizing design and used materials as well as introducing innovative new technologies such as bifacial and half-cell modules or durable Anti-Soiling Coatings (ASC), a strong position can be reached in the emerging energy markets of our future. The following report describes the main challenges and possible solutions for the development of an optimized “Desert Module”.

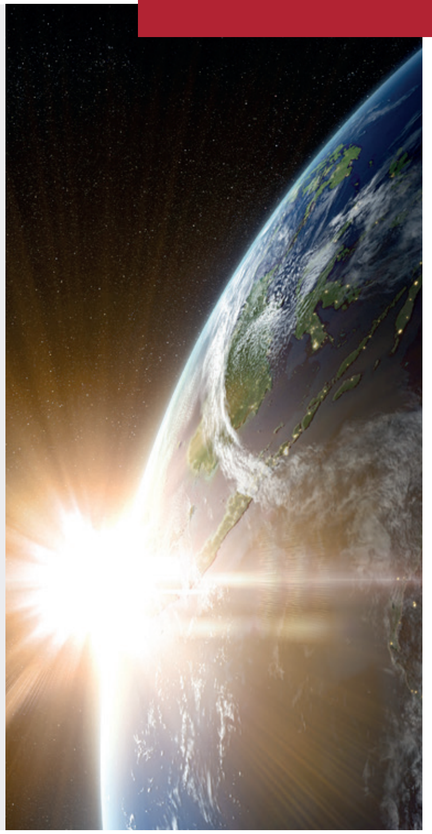
2.2 High Irradiation

High irradiation generates more current and more power in solar modules, but also electrical resistive losses are increase, reoptimizing cell type and size as well as cell interconnectors allows to increase module power and energy yield. Furthermore higher irradiation leads to increased module temperature which reduces energy module. Passive and active cooling of modules is an interesting for increasing energy yield and module performance.

Specific environmental conditions DESERT®/TROPIC®

The sun light received by the earth travels through the earth’ atmosphere. As the optical path length from sun to earth’ equator is shorter as the path length B from sun to Northern Europe, less photons are absorbed by the earth’ atmosphere. This is the reason why in so called Sun Belt regions the irradiation is higher.
High irradiation generates high current and thereby high power in solar modules. But the higher current also leads to a higher resistance in the electrical conductors inside the module and the solar cells. In the J.v.G. technology GmbH DESERT modules the solar cells as well as the busbars between the cells are optimized to reduce the electrical resistance and thus reach an increased module power and energy yield.



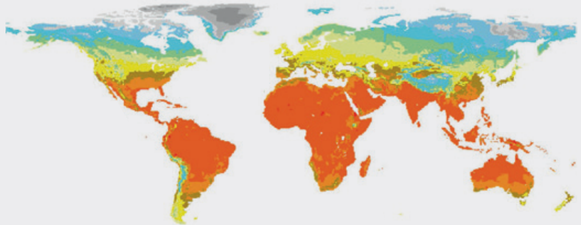


2.3 High UV Irradiation

Due to the reason described in the previous chapter, in the Sun Belt regions, the solar modules must withstand higher UV irradiation doses. Since all polymer materials are in general sensitive to UV illumination, the materials for DESERT modules must be carefully selected to resist this impact. Regarding standard module materials, high UV doses can lead to brittleness of backsheets, as well as browning of EVA material. The J.v.G. technology GmbH Diamond Desert foil as well as the DESERT backsheet have excellent durability properties under UV exposure.

2.4 High ambient temperature

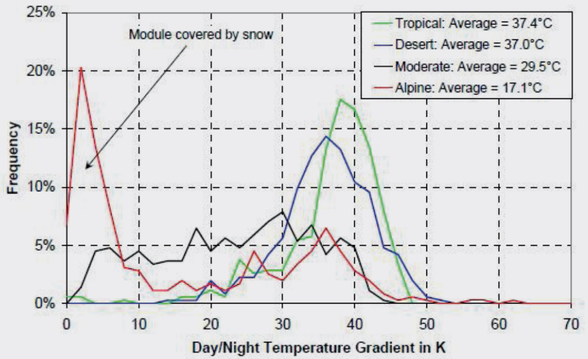
In the Sun Belt regions, the high irradiation leads to a high ambient temperature, and therewith a high module temperature. Due to an intrinsic property of the silicon, the module power decreases linearly with increasing temperature, which is a well known fact in the PV industry. The parameter that describes this behaviour is the so-called temperature coefficient. The J.v.G. technology GmbH DESERT cell has a very low temperature coefficient compared to standard solar cells.
Another approach how to meet the problem of decreasing power at higher temperatures is the cooling of PV modules. Here J.v.G. technology GmbH offers a DESERT Hybrid module (–> 3.3).

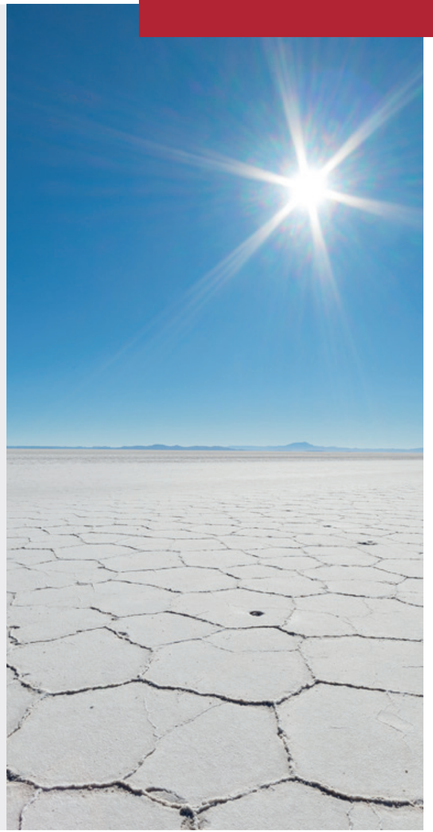


Annual Average Temperature

2.5 High temperature change

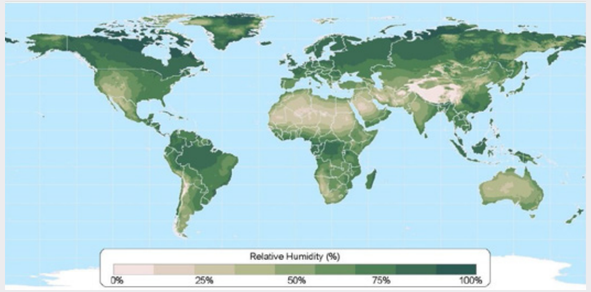
Besides the high ambient temperature, another challenge in regions with extreme climates are the high temperatures changes. In desert or tropical locations, temperature gradients of up to 40°C between day and night occur quite frequently. As a PV module consists of materials with different mechanical behaviours, the high temperature gradients lead to thermomechanical stresses inside the module. Especially the cell connectors are thereby weakened. Using of pretreated and non-crimped connectors or using half-cells can reduce cell connector breaks.



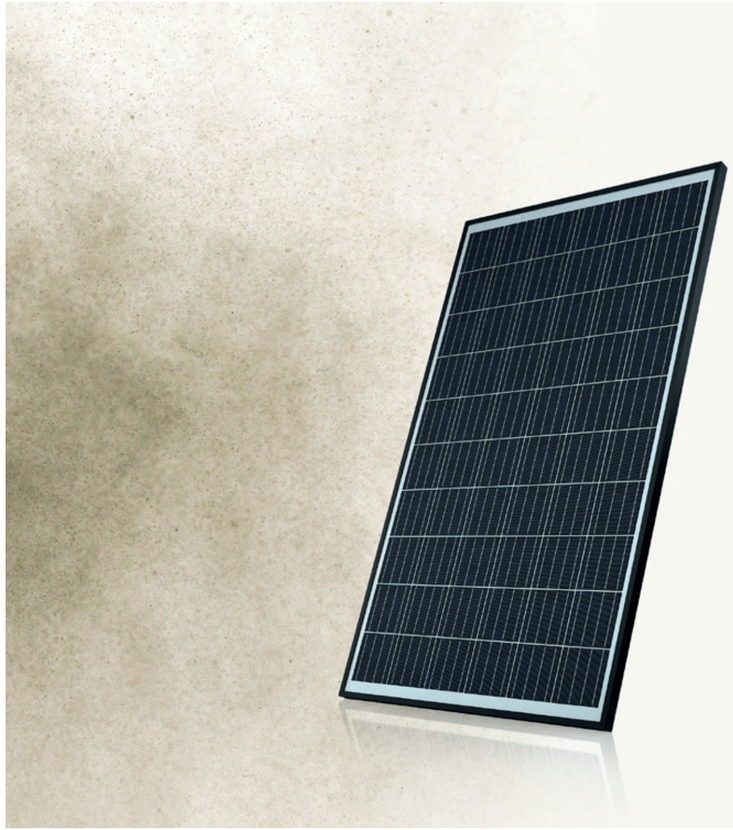


2.6 Relative Humidity

Even in desert regions the relative humidity can get very high in the morning hours, reaching values of up to 100% relative humidity in January. Relative humidity causes, due to delamination of backsheet and encapsulant, lesser adhesion of glass or junction box and can cause safety issues. Moreover, in standard encapsulants penetrating moisture can rinse certain additives, whereby degradation can be taken place. All these processes will be accelerated by high ambient temperatures.
The J.v.G. technology GmbH Diamond Desert Foil, together with our DESERT lamination process, prevents moisture penetrating into the module. For this reason, the J.v.G. technology GmbH DESERT modules are very suitable for locations with high humidity.



World map of average annual relative humidity



2.7 Sand and Dust – Soiling

A central aspect in desert regions is the topic soiling. Soiling is a gradual covering process of the module surface by fine particles (sand or dust). Due to this dust layer, incident sunlight will be absorbed or reflected, and less light can be used by the solar cells. The energy yield of the module will be reducing.

Desert areas with high levels of airborne dust can also show high humidity levels, resulting in wet surfaces in the morning caused by dew, combined with drying during the day. These daily humid-dry cycles promote the so called cementation process, which significantly increases particle adhesion at the surfaces of PV modules and therefore greatly influence soiling. Cementation is one of the most important reasons for high dust accumulation on surfaces, since these crusts adhere too strong to be removed by natural cleaning through wind. As a result after cementation, the surfaces mostly have to be cleaned with high amounts of labour and water, which is time consuming and causes high costs.

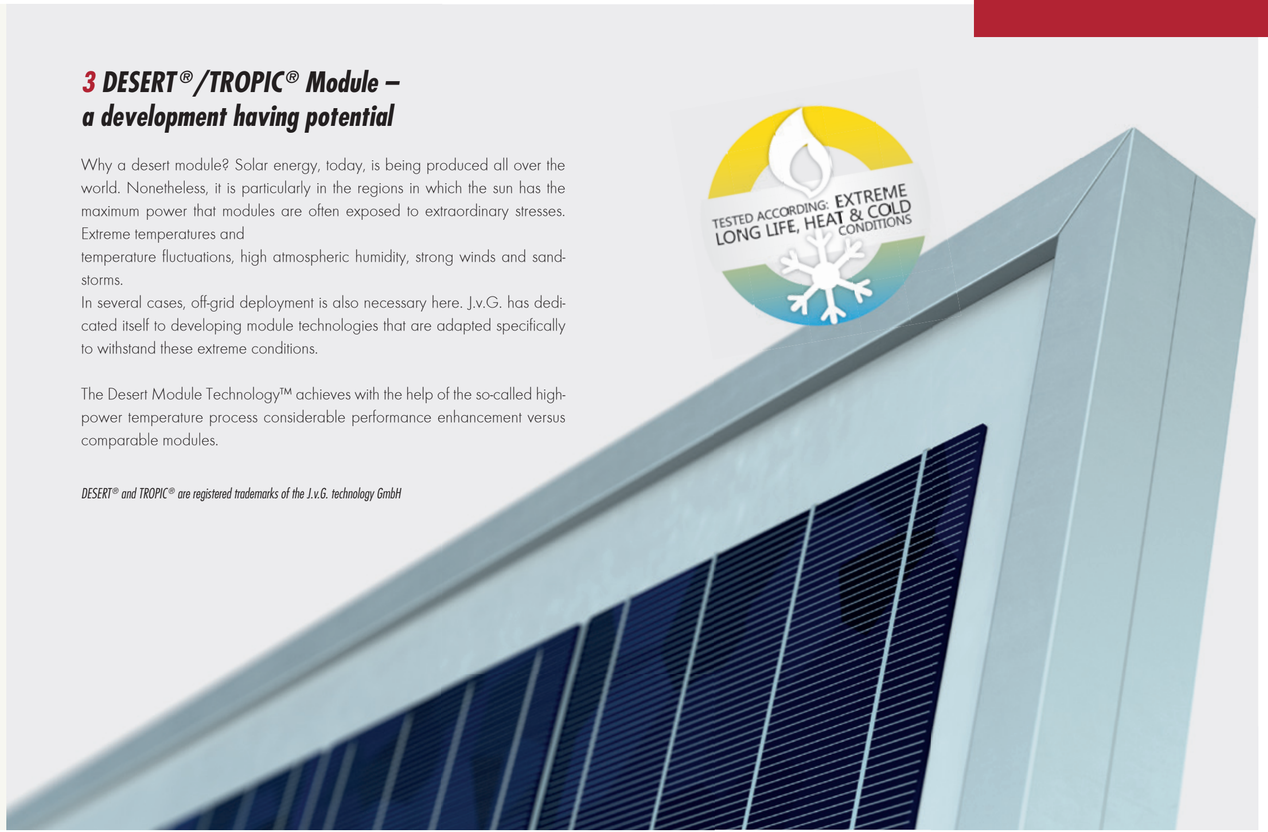
In a current research project, J.v.G. technology GmbH works together with a glass supplier on an anti soiling solution for the module glass surface, to reduce soiling and cementation and thus reduce cleaning costs.

3 DESERT®/TROPIC® Module – a development having potential

Why a desert module? Solar energy, today, is being produced all over the world. Nonetheless, it is particularly in the regions in which the sun has the maximum power that modules are often exposed to extraordinary stresses. Extreme temperatures and
temperature fluctuations, high atmospheric humidity, strong winds and sandstorms.
In several cases, off-grid deployment is also necessary here. J.v.G. has dedicated itself to developing module technologies that are adapted specifically to withstand these extreme conditions.

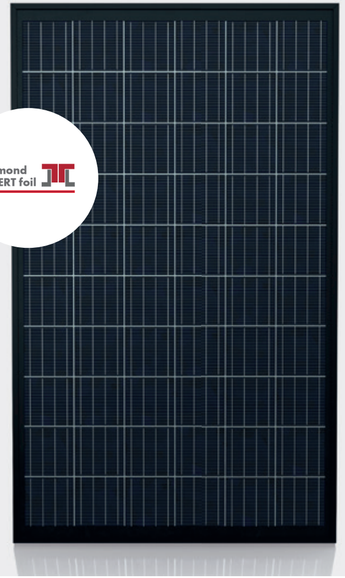
The Desert Module Technology™ achieves with the help of the so-called high-power temperature process considerable performance enhancement versus comparable modules.

DESERT® and TROPIC® are registered trademarks of the J.v.G. technology GmbH



3.1 DESERT-1, DESERT-2 PV panel, DESERT-3 PV panel ans DESERT-4 PV all

DESERT-1: Module designed in glass/foil structure. With Diamond DESERT foil. Standard version.
DESERT-2 PV panel: Panel/module designed in glass/glass (2 mm) structure with Diamond DESERT foil. Premium version.
DESERT-3 PV panel: Panel/module designed as Hybrid module; means PV combined with thermal collector.
DESERT-4 PV all: Panel/modules designed with DESERT solar all; in mono or multi version. With Diamond DESERT foil.



3.2 DESERT-5 PV extensions

Panel/modules designed with DESERT components:

- DESERT plug & save
- DESERT solutions; power plants
- etc.

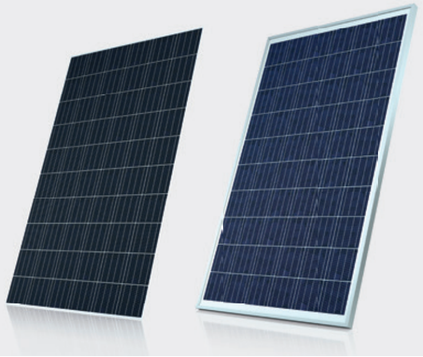
With Diamond DESERT foil.

3.3 DESERT-6 TRACKER

3.4 DESERT-7 INVERTER

3.5 DESERT-8 BATTERY

3.6 TROPIC panel



4 General Benefits of the J.v.G. DESERT® & TROPIC® Module

- High temperature up to 125 °C continuous
- Long service life: up to 75 years, guaranteed 45 years
- 100 % recyclable
- Higher yield (in 30 years over 50%)
- At present, already 5 % more power than conventional modules
- PID free
- anti soiling
- sandstorm resistant
- anti reflex

PID free

Potential-induced degradation stands for the voltage-related degradation in power in crystalline photovoltaic modules cause by so-called leakage currents. In case of high system voltages in the region of 1,000 Volts, there may be leakage current in the module, i.e. charge carriers flow through the embedded material and the backside film. This may lead to electrochemical corrosion and thus, causes loss of power in the module.
The effect occurs particularly at high temperatures and high levels of atmospheric humidity (see the diagram on the right); it may cause loss in power of up to 80 %.

Our measuremants showed 100% no PID. Tested at J.v.G. technology GmbH laboratory.

May 2014

Hans Thoma, Head of J.v.G. technology GmbH

5 DESERT Technology with J.v.G Diamond DESERT Foil

Continuous research and development plays a major role in opening up new possibilities in the manufacturing of solar modules. At J.v.G. technology GmbH we consider it our job to be a pacemaker in this process.
For this reason, the data and measurements given in this product data sheet can be subject to change at short notice. No legal claims may be derived from the contents of these product data sheets. J.v.G. technology GmbH assumes no liability for the usage of the information contained therein or for any consequences resulting there from.

DESERT Advantages

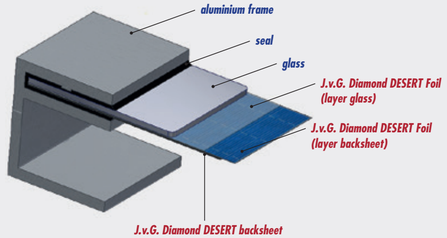
- 100% no PID
- Maximum (sustained) temperature 125°C average and 145°C (maximum 5 minutes)
- Proven German/Bavarian quality

Processing Advantages

No crosslinking during lamination

- Up to 30% reduced cycle time
- Increased yields and capacity
- reduced conversion costs

Photovoltaic using J.v. G.Diamond DESERT Foil



Performance Advantages

J.v.G. Diamond DESERT Foils provide significantly improved electrical performance. High volume resistivity and low leakage current improve electrical insulation and enable „PID Zero" performance. As illustrated in the figures below, improved electrical performance results in increasing energy yield.

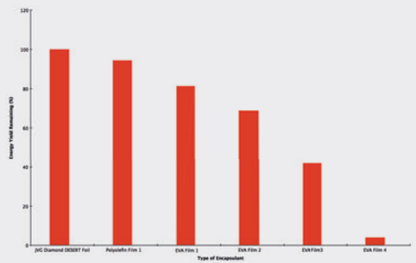
Key Technical Attributes

- 10-20x lower Water Vapor Transmission Rate (WVTR)
- Outstanding Volume Resistivity
- No generation of acetic acid
- Non-yellowing

Performance Advantages

- Significantly reduced degradation rates
- „PID Zero"performance

PID Performance (85% RH, 85°C, -1000V, 48 Hours)



>3% more power with

- J.v.G Diamond Desert Foil layer glass +3%
- J.v.G Diamond Desert Foil layer backsheet +3%
- J.v.G Diamond Desert Foil backsheet +3%

Nano coating in Foil we get more then 3% more power output as "best EVA foils". Converting/shifting of photons is the key technology to make it available for solar cell conversion. Material is in internal tests (>1000 cycles proven) and in certification process. Ask for delivery time for your special need.

6 DESERT® & TROPIC® turnkey production

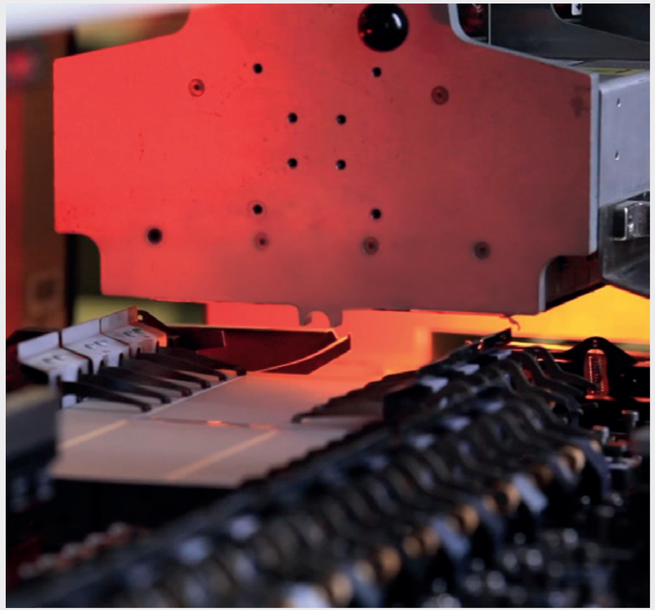
Mono-crystalline or poly-crystalline – which module type is better? This question, in fact, cannot be answered since it depends on the area of application.

The difference lies, to begin with, in the crystal structure: poly-crystalline cells consist of wafers that do not have the same orientation all over the crystals. They are produced, for example, using moulding techniques.

With an efficiency of up to 27 percent, mono-crystalline solar cells are the most effective solar cells with direct sunlight. They are highly suitable when only limited roof surface area is available or when very high power needs to be achieved. However, mono-crystalline modules are comparatively expensive on account of their sophisticated production techniques. And: their performance deteriorates with diffuse light. This is a disadvantage particularly in case of roof surface areas that are not directly aligned towards the south.

Poly-crystalline modules, in contrast, do not have such a high level of efficiency, but they are considerably cheaper. This is why they are also the most frequently installed modules at present. They crystal structure is characteristic; it allows the poly-crystalline solar modules to reflect strongly in sunlight.

Our turnkey production is flexibel for all types and all sizes. Also high flexibel for panel size.



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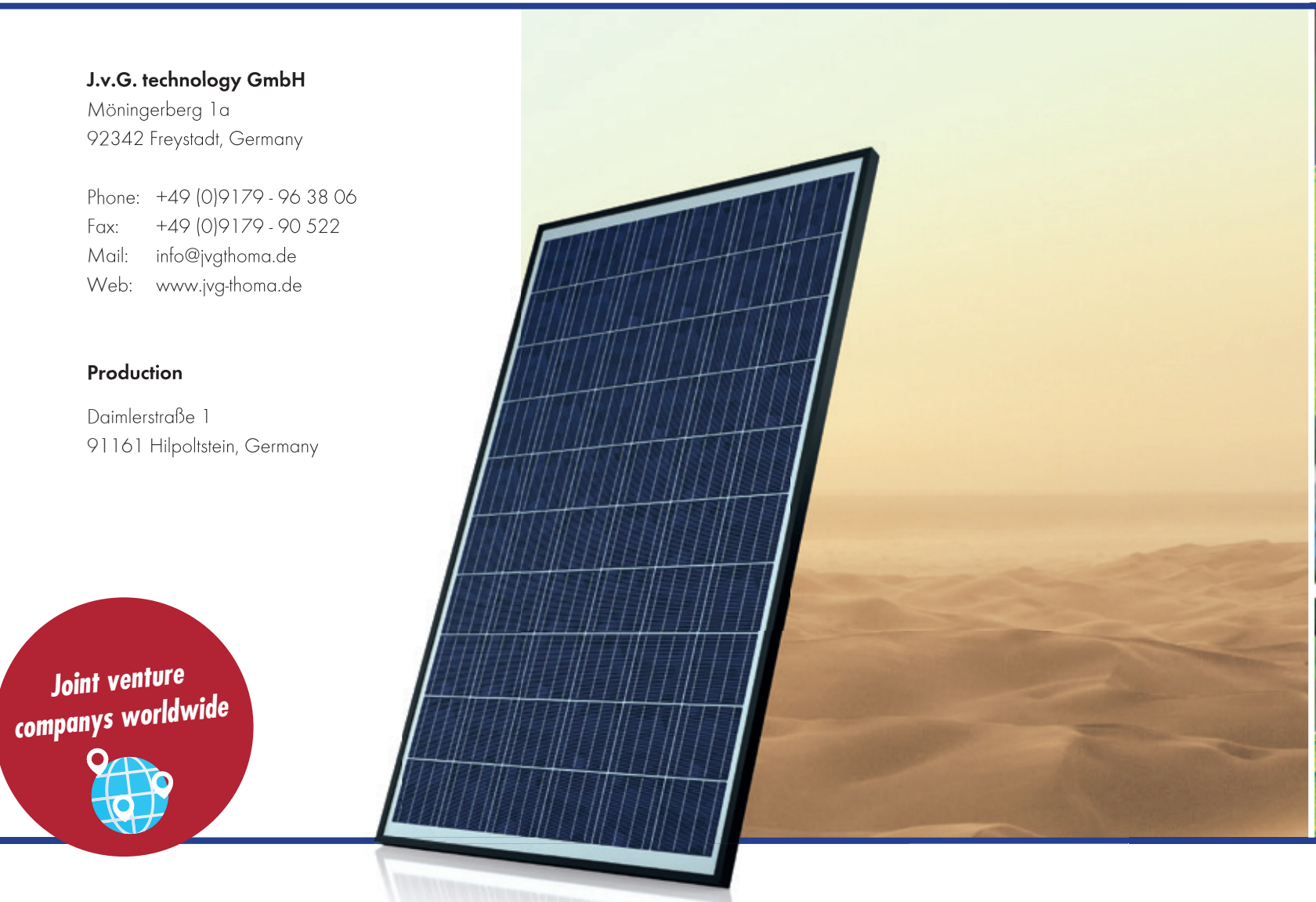

Joint venture companys worldwide

High-temperature Module: Process Technology