



Interconnection Technologies

**High Efficiency Matrix
Shingle Modules**

Perfectly Suited for Integrated Photovoltaics

With their high efficiency, matrix shingle modules offer maximum yield on a limited amount of space. If modules are integrated into the envelope of vehicles or buildings, not only efficiency but also a high power yield in the case of partial shading, a visually appealing appearance and easy scalability of the module size are required. Fraunhofer ISE has developed the matrix shingle technology especially for such applications.

The matrix shingle connection of silicon solar cells offers a homogeneous overall appearance due to the completely covered module surface, which can be optimally integrated into vehicles or buildings in a creative way. In matrix technology, cell strips are connected to each other in a staggered shingle technique, in the pattern of masonry.

Our Services for Module Manufacturers and Architects

- in-house trial days: access to the equipment, our experienced technical staff and a selection of different adhesive materials
- expertise in commercially available adhesives, process technology and quality control
- production and testing of prototype modules and small series in shingle technology
- development and optimisation of module design and interconnection
- characterizations and reliability tests

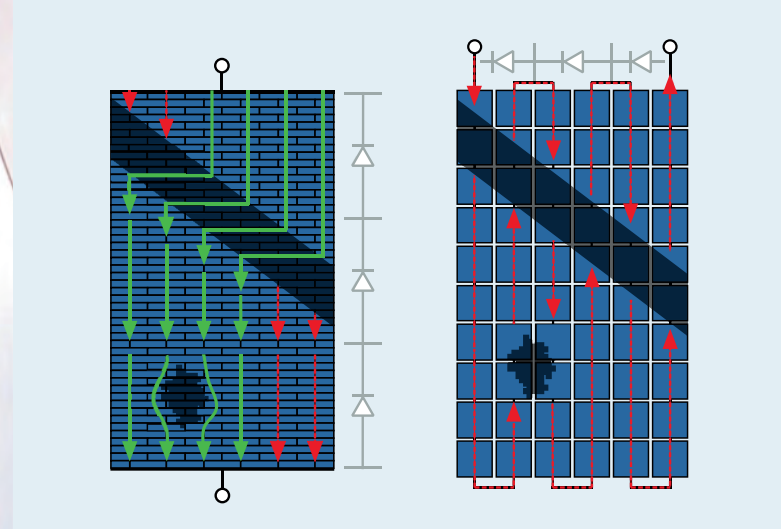


Matrix shingle modules installed as façade elements.
© M10 Industries

Advantages of the Matrix Shingle Technology

With the matrix connection, the area can be optimally utilized by staggering the shingle solar cells laterally; in addition, a very homogeneous appearance results. The cells are electrically connected in series and simultaneously in parallel. This network of connections ensures that in the event of shading, the current flows around the shaded areas. With conventional cell interconnection the entire string is affected.

- 2 - 6 %_(relativ) higher module efficiency than conventional half-cell modules (maximum area utilization, low resistance losses)
- homogeneous appearance
- 100 % lead-free cell interconnection
- excellent module reliability
- flexibly adaptable to building and facade geometry
- up to 110 % more power in partial shading than conventional half-cell modules
- manufacturing costs comparable to ordinary soldered joints



Left: In the matrix shingle module, the current flows around shaded areas, right: in the conventional module, the current flow is interrupted by shaded areas.

Individual Coloring

The modules can be produced in different colors with high color saturation using the MorphoColor® coating developed at Fraunhofer ISE. The transmission of solar radiation and thus the efficiency of the colored modules is over 90 % of the value of comparable modules. The solar cells underneath are virtually invisible. This opens up a wide range of design options for architects and vehicle manufacturers.

Production in the Novel Industrial Shingle Matrix Stringer

We use a fully automatic matrix shingle stringer from the company M10 Industries AG, which was developed in the publicly funded joint project »Shirkan«. The machine concept of M10 allows the connection of 12,000 shingle solar cells per hour. We produce prototypes as well as small series according to your design ideas and are happy to support you in the development of new module concepts.

Current Projects

“Shirkan 2” – Matrix Shingle Technology for the Future of Photovoltaics

The aim of the project is to increase productivity in solar module manufacturing for high-efficiency shingle solar modules with a novel, particularly efficient matrix interconnection topology. Further aims:

- development of a fully automated stringer for matrix interconnection of shingle solar cells
- scientific analysis on partial shading behavior
- construction of matrix shingle modules in full format
- technology development for shingle interconnection, electrical and mechanical characterization of shingle connection joints
- module reliability analysis

“Sphinx” – Solar Photovoltaics Integrated Into the Built Environment

The project strives for the innovative integration of photovoltaics in roof tiles, carports, noise barriers and building envelopes through the industrial use of matrix shingle technology. Further aims:

- development of a pilot line for the demonstration of the matrix shingle technology
- development of innovative PV module products for integrated photovoltaics

Further Information on Current Projects



Project website “Shirkan 2”



Project website “Sphinx”

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