

## Photovoltaic Industry

The worldwide solar cell industry is booming and increasing its production volume year by year. With the unique non-contact ultrasound air bearing technology, Zimmermann & Schilp Handhabungstechnik GmbH (ZSH) established a completely new dimension for the handling of substrates in the photovoltaic industry.

### As an example, the ZSH solar wafer sorter combines most different tasks:

Non-contact solar wafer/cell singulation and picking from a stack.

Solar cell handling between process steps without contact.

Facilitating two sided optical inspection of the solar cell.

Classifying of the solar cells in quality categories.

Delivering solar cells without contact to several destination stacks.

## Case Study Non-Contact Handling Systems

### We are addressing today's challenges in PV industry

#### Fragile substrates:

Handling during all processes must be gentle enough to prevent microcracks and edge chipping.

#### Thinner and thinner substrates:

Realize transportation possibilities of substrates that may be bent by their own weight.

#### Wedge substrates:

All processes must be tolerant to solar cells of varying thickness.

#### Very short cycle times:

Guarantee optimized cycle times for the interaction of several processes (up to 7000 wafers/h or 0.5 s/wafer).

#### High yield:

Increase yield by minimizing breakage rates (< 70 ppm).

#### On-the-fly-testing:

Integration of high speed measurement equipment.

#### Edge stress:

Avoiding any kind of edge- and surface stress and feed only intact solar wafers through the production line.

#### The trend setter

At home in the photovoltaic industry as well as in the semiconductor and FPD industry, Zimmermann & Schilp Handhabungstechnik GmbH (ZSH) plays a trend-setting role in Europe, Asia and North America. We provide a comprehensive range of products with several revolutionary novelties for non-contact and gentle handling of solar cells and wafers. These solutions are targeting yield increase as well as the profitability of your production lines.

## A Promising New Approach: The Ultrasound Air Bearing

### Advantages of the Ultrasound Air Bearing Technology

High throughput: up to 2 wafers/s

Low cycle times: cycle time: 0.5 s/wafer

Picking/separation distance up to 12 mm

Suitable for thin wafers down to 100 µm

Very low energy consumption

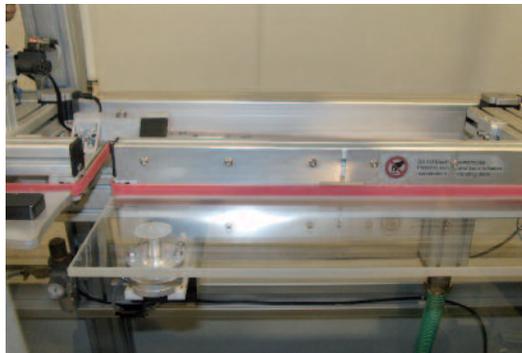
Small footprint

Very low edge load

Homogenous distribution of handling forces, no internal stress inside the wafer

No force peaks

Base for metrology and inspection



Non-contact Linear Track

### Non-contact picker-unit

The non-contact picker module represents an essential part of our production range.

While completely avoiding time intensive pick & place processes, a non-contact ultrasonic singulation is available for our customers to handle solar wafers gently within a cycle time of 0.5 seconds per wafer. Moreover, the picker unit is suitable for different substrate sizes.

The wafer is attracted by a large scale low pressure zone from distances up to 12 mm. At the same time the ultrasound air bearing prevents any contact to the linear track. The wafer is hovering below the track surface and can be moved and accelerated without any friction.

### Non-contact Linear Track

The non-contact handling systems provided by Zimmermann & Schilp can be applied in any process environment. The ambient air or process gas is compressed by the ultrasound. Thus solar wafers or cells are levitated contactlessly along defined tracks.

The non-contact linear transfer track combines optimized transport speed and low cycle times with minimized wafer damage (<70 ppm). The non-contact transport is minimizing wafer stress due to the non-contact, full-surface gripping forces. A belt causes forward motion. The edge-load is only a fraction of the weight of the solar cell.

### In-process-quality-control

In modern solar plants product quality is ensured by fast optical measurement systems. With our non-contact handling devices using glass sonotrodes, we offer the ideal solution for a two-sided substrate inspection. Wafers/Cells can be inspected either in the gap between the sonotrodes (ultrasound air bearings) as well as through a sonotrode made of glass.

# 2 wafers/s

Sorter-Module:  
3 Sorting Units.



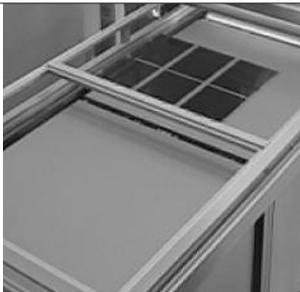
#### Non-Contact Sorter Module

The quality management becomes significantly more complex by the rapid progress in solar industry. With the non-contact solar cell sorter system we offer a respective solution for the industry. By means of the non-contact linear track, solar cells are held from the top side and transported to the correct position over the carrier. Reliability, speed and a very small footprint are some of the key benefits of the sorter system.

#### Non-Contact Glass-Handling

Zimmermann & Schilp not only provides devices for wafer/cell handling. We also offer grippers and conveyors for thin-film PV production:

Glass-Conveyors



#### Large Conveyors:

The non-contact conveyors facilitate a smooth and friction free transport of substrates. The systems are designed as modules which can be assembled to arrays of any length and width.

The devices offer two approaches to realize a double-sided inspection of substrates:

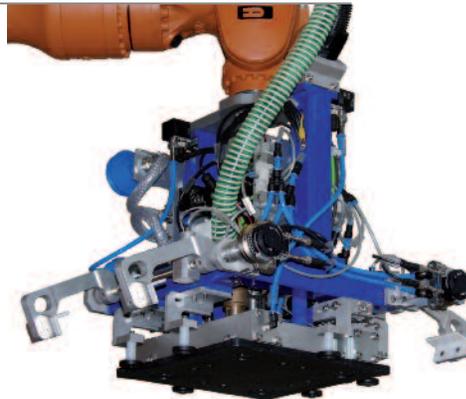
- Intersection of the transfer system with a gap up to 20 mm. This gap can easily be crossed by the substrates while the inspection can be done through this gap (e.g. by optical sensors, line cameras).
- Using glass as material of the transfer system. The substrate can be inspected by optical means through the glass.

#### Glass-grippers for top-side handling:

For top-side-handling the repelling ultrasound forces are used in combination with attracting low-pressure forces. This technique enables an easy-to-use non-contact handling of parts, very much like the familiar top-side-gripping of parts. Additionally flexible parts can be flattened and kept in position and geometry by this technique without any contact to the handling tool.

The substrates are centered by adjustable and moveable side-stops.

Glass-Gripper

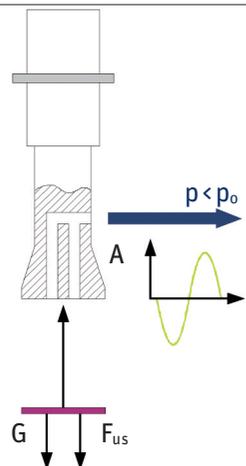


All of our handling systems use the ultrasound air bearing which can be applied in any atmospheric process.

Squeeze-film Levitation:  
Repelling Forces



Combination  
of Physical Effects:  
Top-Side Handling



### Ultrasound

Ultrasound is a vibration at frequencies beyond the upper limit of human hearing ( $f > 20$  kHz). It is generated by transducers which are powered by separate power electronics.

### Levitation, No Cleaning

The levitational effect of our ultrasound air bearing is not comparable to ultrasound cleaning. Ultrasound cleaning requires a fluid. Within that fluid the ultrasound generates voids (partial vacuum bubbles) which are collapsing with enormous energy. This leads to the removal of particles from the surface. In contrast to that, our ultrasound air-film technology needs compressible fluids like process gases or air. The air is compressed in the gap between the part and the handling tool. The film of compressed air is acting exactly like a conventional air bearing — except the losses from generating compressed air, no pumps, pipes and nozzles. The damping air film prevents the vibration energy from being transferred to the part. Thus there is basically no vibration of the part.

### Squeeze-film Levitation: Repelling Forces

The physics of the ultrasound air bearing derives more from fluid dynamics than from acoustic principles. The gas pressure in the gap between the workpiece and the vibrating surface of the sound generator rises due to the cyclic compression and decompression of the thin gas film. Therefore it is necessary to create a uniform vibration pattern in order to generate equal levitation forces throughout the whole vibrating surface. This is one of the core competences of Zimmermann & Schilp: we trim the sound! Using the squeeze-film levitation significant repelling forces can be generated between the sound source and the workpiece. Therefore the workpiece can be moved without any friction. The ultrasound technology uses the ambient air or (process) gas at the interface for the pressure generation.

### Combination of Physical Effects: Top-Side Handling

Many handling processes need the use of attracting and repelling forces at the same time, e.g. top-side handling. In these cases repelling ultrasound forces are used in combination with attracting low-pressure forces. This technique enables an easy-to-use non-contact handling of parts, very much like the familiar top-side-gripping of parts. Additionally flexible parts can be flattened and kept in position and geometry by this technique without any contact to the handling tool.

Zimmermann  
Schilp

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