



COMPETENCE IN THIN AND ULTRA-THIN WAFER PROCESSING AND HANDLING  
BASED ON TRANSFER ELECTROSTATIC CARRIER (T-ESC®) TECHNOLOGY

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## . PROTEC CARRIER SYSTEMS

ProTec Carrier Systems GmbH (PCS) is a young, highly innovative company specialized in the development, production, and marketing of systems and components for the transport as well as processing of thin and ultra-thin substrates. These applications are designed for the semiconductor, photovoltaic, and display industries in form of the worldwide patented Transfer ElectroStatic Carrier (T-ESC®) Technology.

Great emphasis is placed on applications where conventional, temporary bonding systems fail or do not function adequately, such as under high-temperature and/or vacuum conditions. Some processes become viable only by introducing T-ESC® Technology, such as Back Side Gas Cooling (BSGC).

The company, founded in 2008, has its premises in Siegen, Germany.



**Coulomb's Law:**

Clamping Force  $F_c$  depends on:

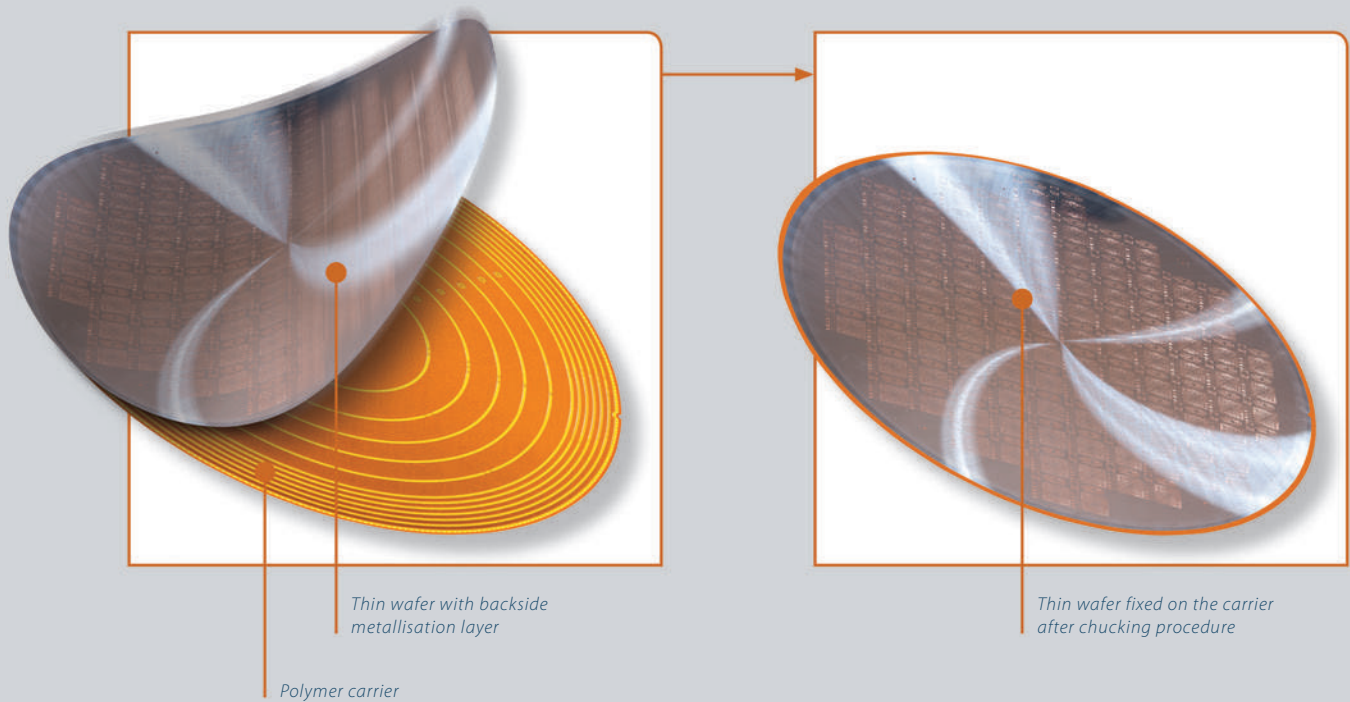
- Charges  $Q_1$  and  $Q_2$
- Space/gap  $r$  between the charges
- relative dielectric constant  $\epsilon_r$

$$F_c = \frac{Q_1 \cdot Q_2}{4 \cdot \pi \cdot \epsilon_r \cdot \epsilon_0 \cdot r^2} \cdot \vec{r}_0$$

$$F_c = \frac{Q_1 \cdot Q_2}{4 \cdot \pi \cdot \epsilon_r \epsilon_0 \cdot r^2} \cdot \vec{r}_0$$

## Basics

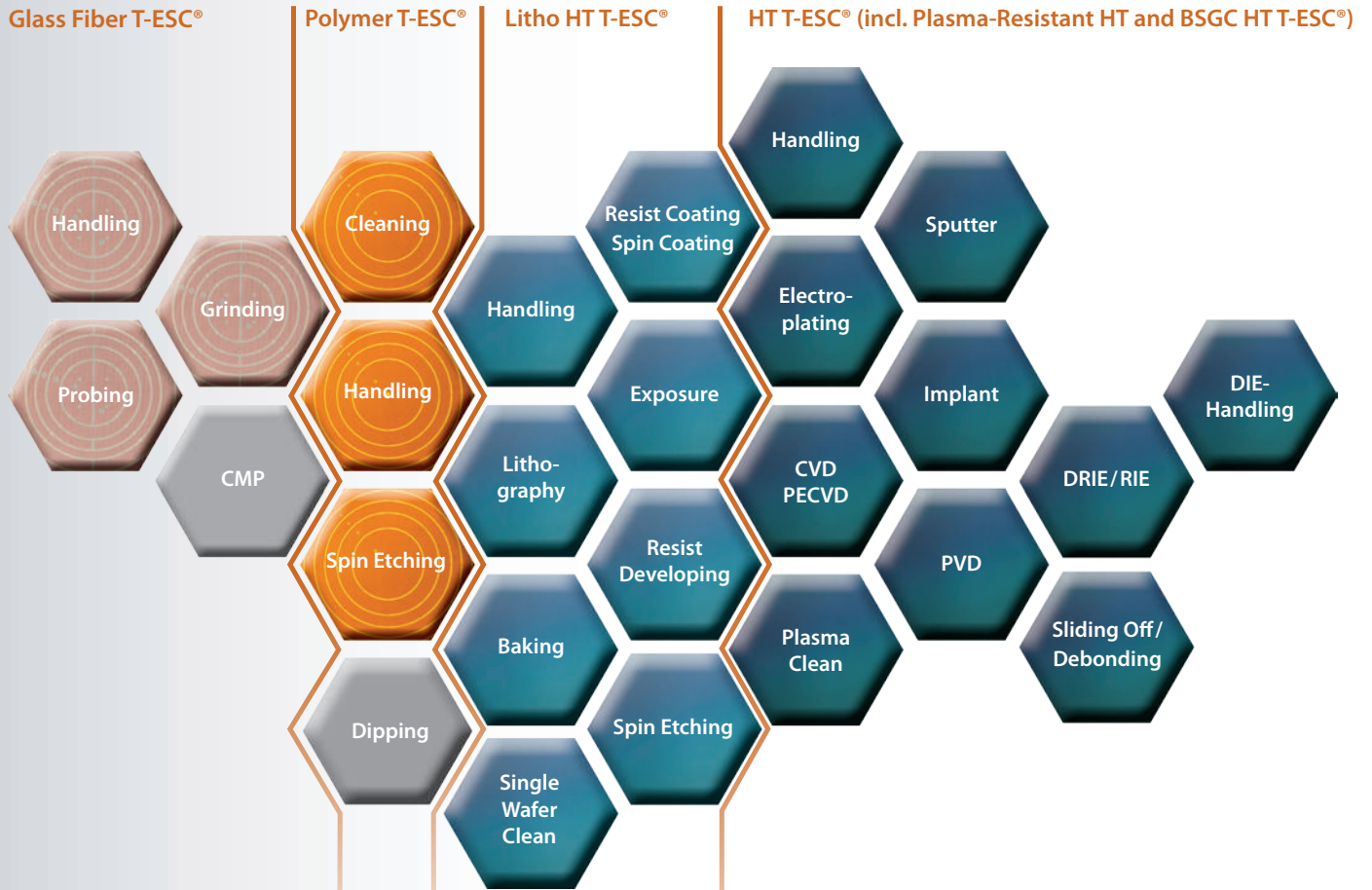
PCS's Transfer ElectroStatic Carrier (T-ESC®) Technology provides safe and easy handling as well as processing of thin and ultra-thin substrates. T-ESC® Technology is based on using an electrical field to apply an electrostatic force (Coulomb force) on materials of rather low conductivity. The mobile electrostatic carriers (T-ESC®) developed by PCS establish such a field and chuck especially thin substrates (< 50µm) over a long period of time (up to 50 hours). The quick release at the end of the process leaves absolutely no contaminants on the substrate. Organic residues caused by the use of tape or by bonding – therefore requiring additional cleaning processes – are thus avoided. All existing standard tools, equipment, and processes remain fully utilizable. Warping and bowing of thin substrates are avoided during the entire process thanks to carrier protection. PCS offers a great variety of carriers suitable for many processes in the semiconductor and photovoltaic manufacturing industry.



## T-ESC® Solutions

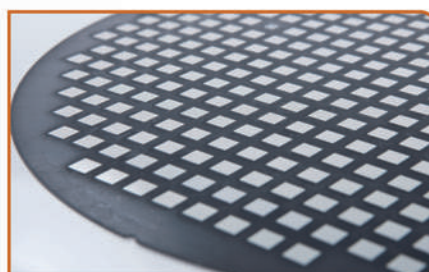
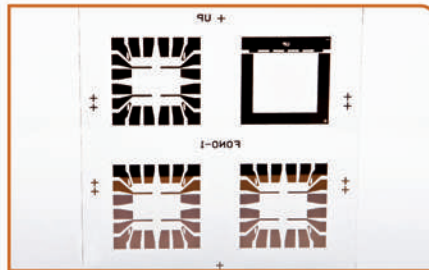
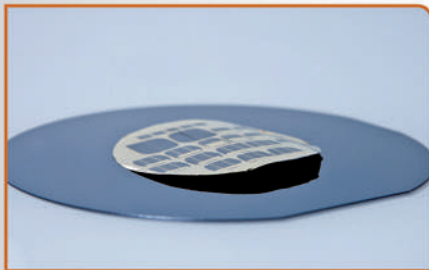
- Bow Elimination
- Bridging (Adapter Tool)
- Sliding Off
- "Sandwich Chucking" with Masks
- Transparent Substrates/Carriers
- Deframing/Easy Flipping
- Transportation/Storage
- Back Side Gas Cooling (BSGC)

## Process Applications



## Chuckable Substrates

- Standard wafers (semiconductor, photovoltaic)
- Thin wafers (50 µm tested), Taico wafers
- "Compound wafers"
- Textured surfaces
- GaAs/SiC (with or without GaN)
- ITO coated substrates (quarz, sapphire, glass)
- Pyrex 7740
- Bonded wafers
- Masks (e.g. stencil)



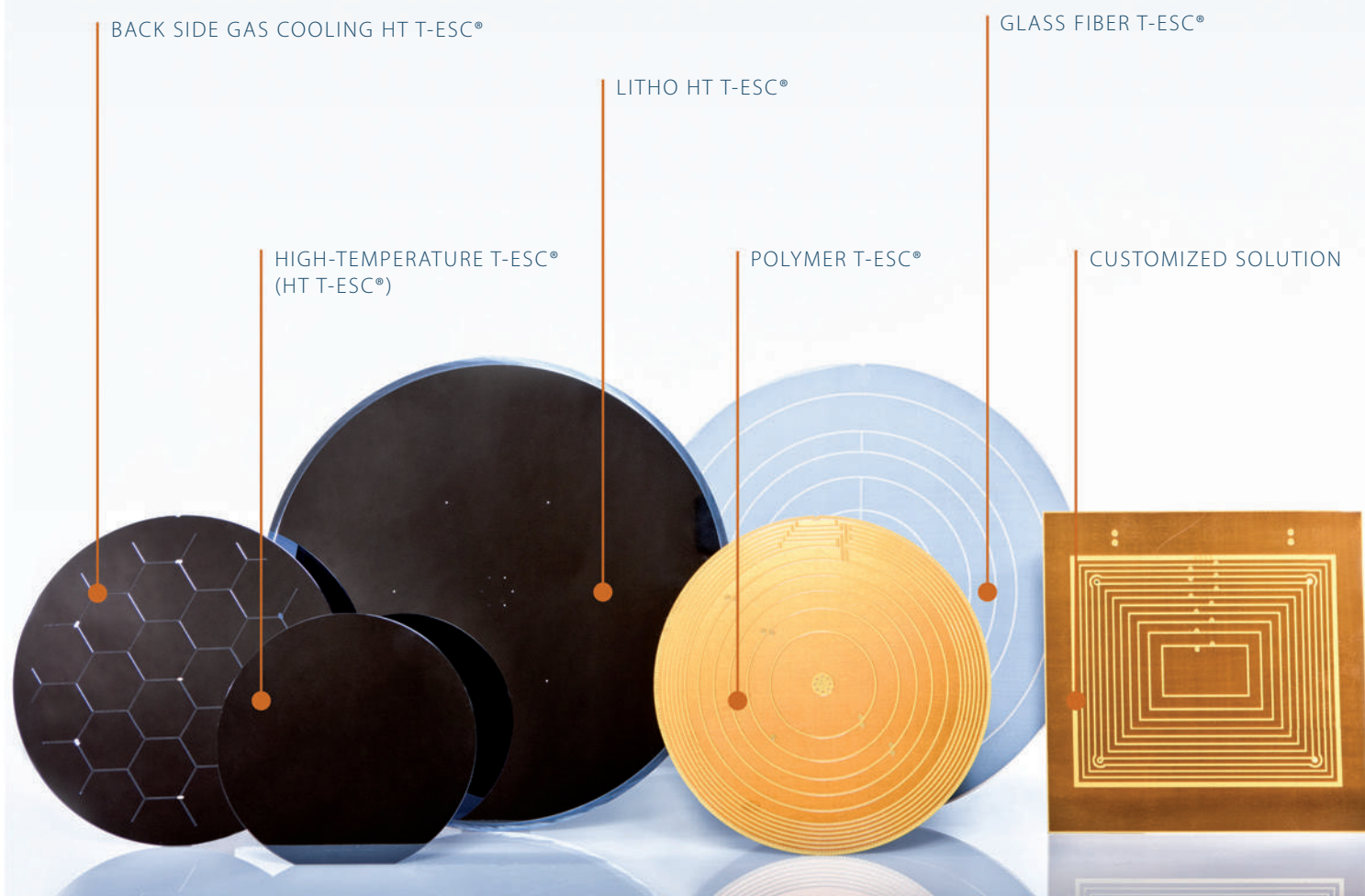


T-ESC® Technology offers safe and easy handling as well as processing of thin and ultra-thin substrates. The basic concept behind this reversible chucking technology involves using electrostatic force to clamp thin and ultra-thin flexible wafers onto robust carriers (T-ESC®). Such wafer-carrier packages can be handled and processed like wafers of standard thickness. Therefore, existing standard cassettes, handling tools, and fabrication equipment can be used without modifications. Warp and bow of thin and ultra-thin substrates are eliminated.

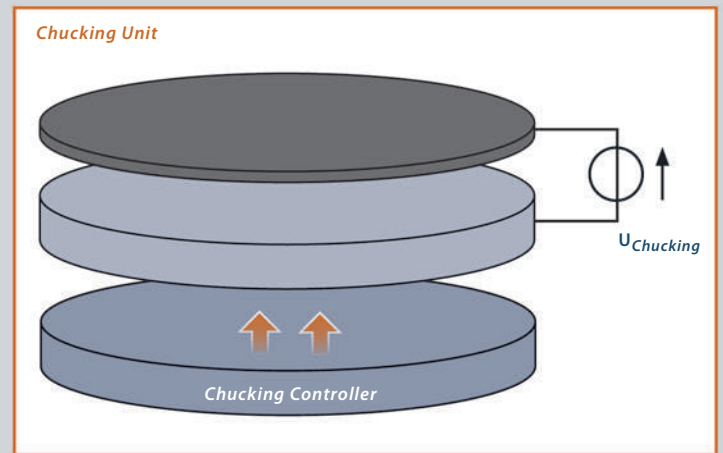
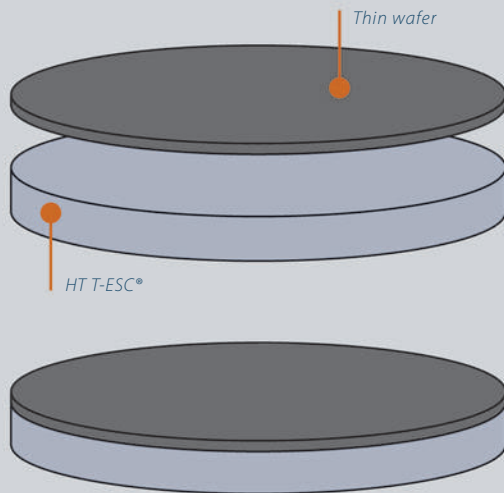
PCS offers different types of carriers (T-ESC®) applicable to a great variety of process applications.

### Technical Data:

- All carriers are available in sizes 4", 6", 8", and 12" according to the SEMI standards
- Moreover, non-standard sizes, substrates for photovoltaic purposes, or display applications can be customized



## . TRANSFER ELECTROSTATIC CARRIER (T-ESC®)



SEMI conform package after chucking  
Mounted wafer ready for application

- Thickness of package ~750  $\mu\text{m}$
- Package can be handled and processed by standard equipment

## HIGH-TEMPERATURE T-ESC® (HT T-ESC®)



### Unipolar carrier based on silicon wafers:

- Solution for thin wafer support during processes involving high-temperature impact (up to 450°C), vacuum, and plasma environment
- Compatible with common bipolar stationary chucks

### Typical Applications

- PVD/CVD
- Implanting
- Dry etching
- Lithography (partially)
- Plasma cleaning
- Electroplating
- Annealing of wafer surface

### Qualified Equipment

- STS Pegasus
- Varian E500
- Semitool Equinox
- Oxford Plasmalab 80 Plus
- BCP LLS802
- Applied Materials PVD Cluster Tool
- Various CVD tools
- etc.

### Additional Information:

The HT Carrier is a standard silicon wafer adhering to SEMI standards. By applying a specific coating to the bulk material (using standard semiconductor materials), the High-Temperature wafer support system for thin and ultra-thin substrates is achieved.

### Advantages of HT T-ESC®:

- Low contamination
- High flatness
- Compatibility with existing handling systems (transport cassettes, vacuum, Bernoulli or mechanical end effectors, etc.)



## LITHO HT T-ESC®

(MEMBER OF THE HT T-ESC® FAMILY)



Fluid residues between substrate and carrier are avoided. In addition to the benefits offered by the standard HT T-ESC®, the Litho HT T-ESC® is an adapted solution fostering thin wafer support during the whole lithography process.

### Typical Applications

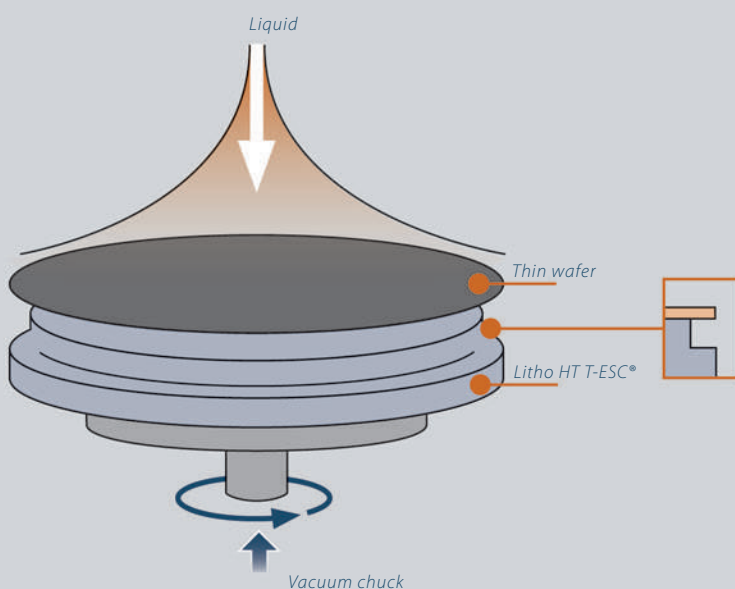
- Photoresist coating
- EBR
- Baking
- Exposure
- Developing

Moreover, the following applications are supported as well:

- Spin cleaning
- Spin etching

### Qualified Equipment

- SUSS ACS300Plus
- SUSS MA200Compact
- SSEC3300
- Various single-wafer cleaners





## . TRANSFER ELECTROSTATIC CARRIER (T-ESC®)

### PLASMA-RESISTANT HT T-ESC®

(MEMBER OF THE HT T-ESC® FAMILY)



Enables longer processing times for clamped thin wafers in plasma processes thanks to adapted and optimized edge protection.

#### Typical Applications

- Dry etching (DRIE/RIE)
- Implant
- Metal deposition

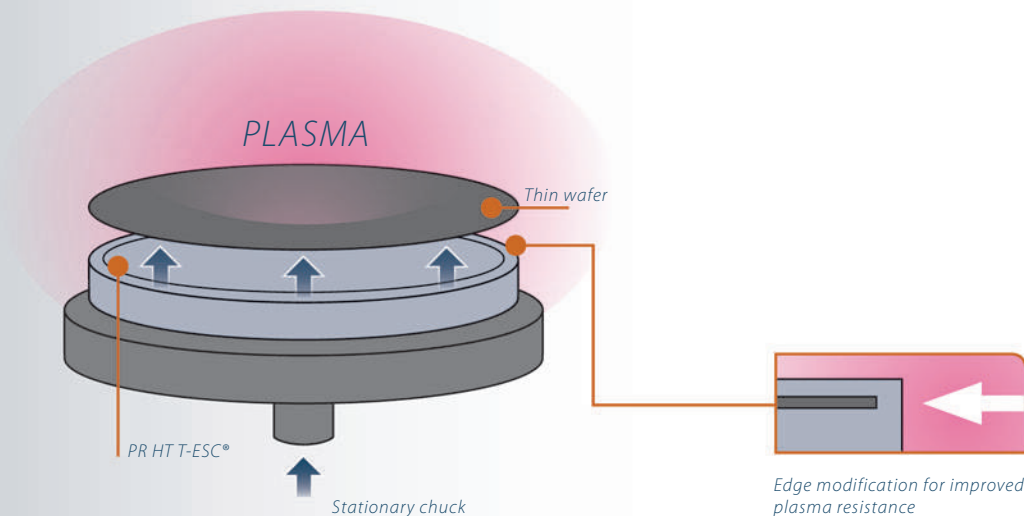
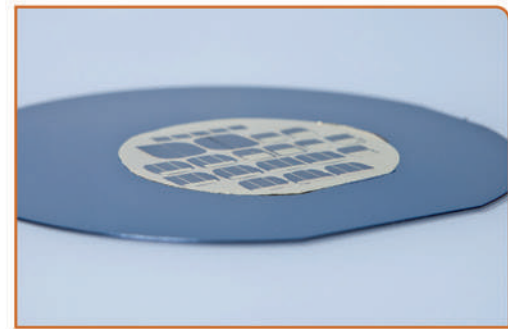
Furthermore, the same applications supported by the standard HT Carrier are also supported by the PR HT T-ESC®.

#### Qualified Equipment

- STS Pegasus
- Varian E500

#### Option: Adapter PR HT T-ESC®

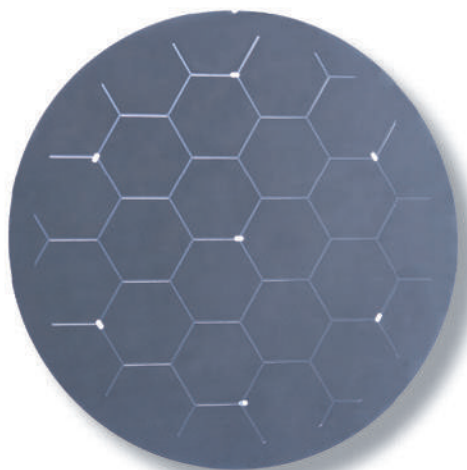
Enables in addition to the benefits of PR HT T-ESC® also the possibility to handle and process smaller-sized substrates on bigger-sized tools, e.g. 6" sample on 8" tool.





## BACK SIDE GAS COOLING HT T-ESC®

(MEMBER OF THE HT T-ESC® FAMILY)



Optimized for processing of clamped thin wafers during exothermal processes with controlled temperature development due to active and direct Back Side Gas Cooling (He/Ar) of the thin wafer device.

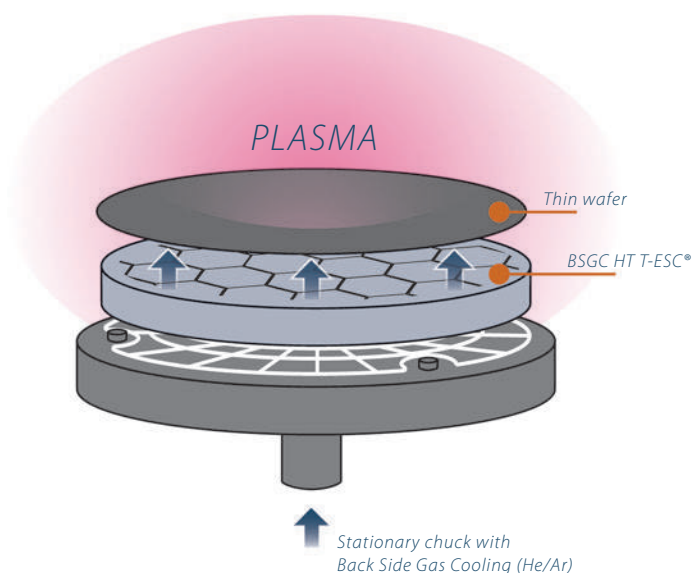
### Typical Applications

- Metal deposition (Cu/Ta, etc.)
- Dry etching (DRIE/RIE)
- High dosis/energy implant

The same applications supported through the standard HT Carrier are likewise supported by the BSGC HT T-ESC®.

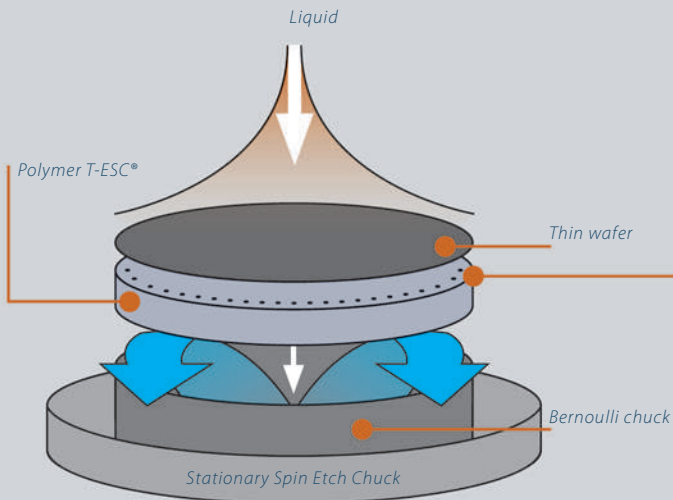
### Qualified Equipment

- AMAT Endura
- STS Pegasus



## . TRANSFER ELECTROSTATIC CARRIER (T-ESC®)

### POLYMER T-ESC®



#### Consists of compounded polyimide foils with embedded and sealed copper layers:

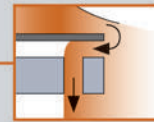
- Protects against penetration by liquids between wafer and carrier
- Resistive against commonly used chemicals in semiconductor manufacturing

#### Typical Applications

- Spin etching
- Spin cleaning
- Spin coating
- Optical inspection
- Probing

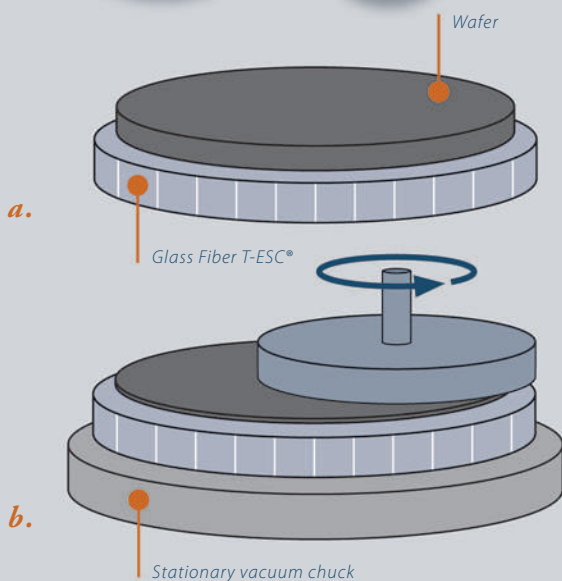
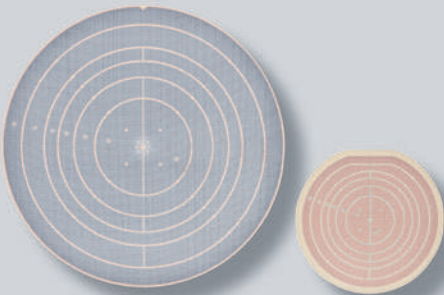
#### Qualified Equipment

- SEZ: RST 101, RST 102, RST 103



Edge design and resist flow

### GLASS FIBER T-ESC®



#### Bipolar carrier based on glass fiber:

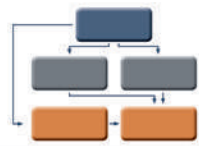
- Enables tape-free grinding as well as thinned substrate/wafer handling in a protected manner after the grinding process is completed
- Resistive against slurry
- Flatness (TTV) < 2  $\mu$ m

#### Typical Applications

- Grinding
- Optical inspection
- Probing

#### Qualified Equipment

- Disco DFG 840/850
- G & N Multinano 3-300

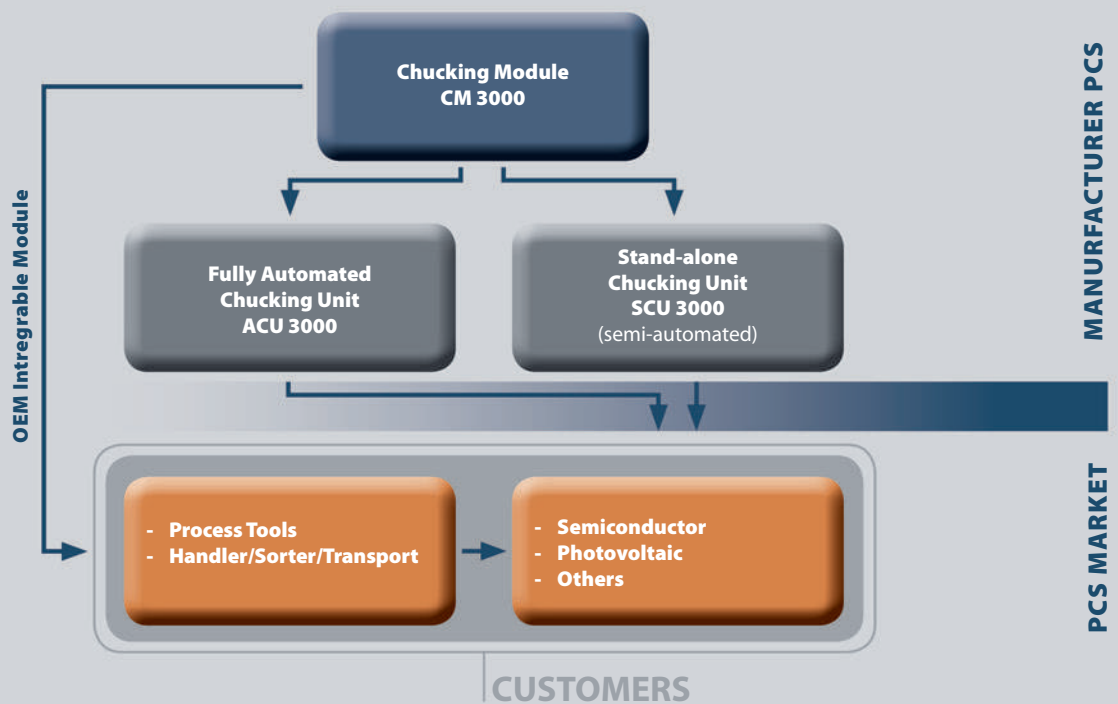


## AUTOMATED CHUCKING SYSTEMS

Automated chucking system for use in **three different ways**:

- individual chucking module CM 3000  
integrable into other existing systems, e.g. process tools
- fully automated chucking unit ACU 3000
- stand-alone chucking unit SCU 3000

### PCS DISTRIBUTION CHANNEL



#### Technical Features:

- Non-contact substrate/wafer handling as per Bernoulli's principle with high precision alignment
- Throughput of up to 120 carrier packages per hour

#### Process Media:

- Power supply: 100–240 V
- Pneumatics: N<sub>2</sub> or CDA
- Vacuum

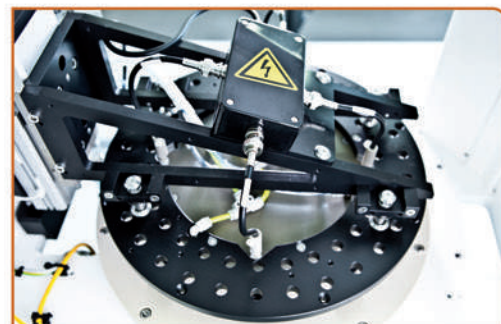
**Clean Room Class:** 100, 10

**Communication:** SEMI Standard SECS/GEM

**Applications:** Silicon wafers in sizes 6", 8", and 12" as well as other substrates (see page 5)

## . AUTOMATED CHUCKING SYSTEMS

### CHUCKING MODULE CM 3000



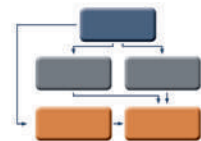
#### Electrostatic chucking/de-chucking module:

- Integrable into other systems, e.g. process tools, due to standardized interfaces
- Existing, standardized systems can be used for processing thin and ultra-thin substrates/wafers without any system- or process-related modifications

#### Technical Data:

Machine Dimensions: L x W x H: 540 x 330 x 640 mm

Weight: 20 kg



## FULLY AUTOMATED CHUCKING UNIT ACU 3000



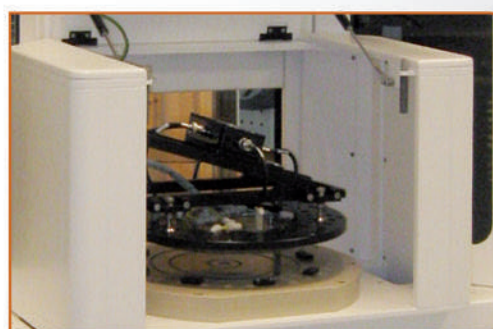
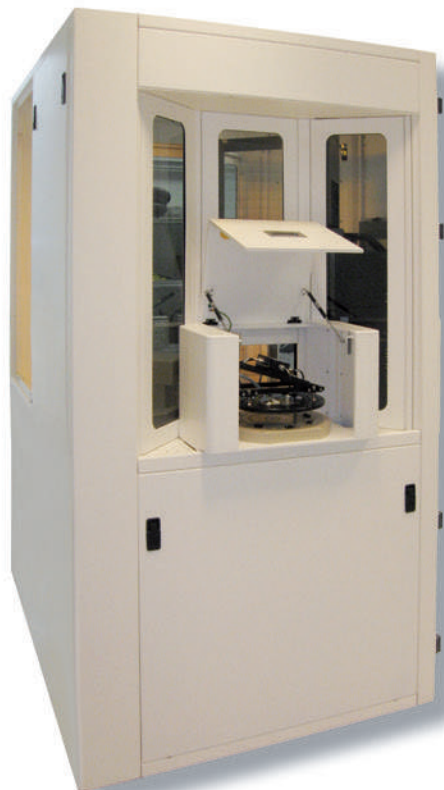
**Fully automated electrostatic chucking/de-chucking unit, consisting of:**

- Chucking Module CM 3000 as main unit
- Thin Wafer Sorter/Handler as framework

**Technical Data:**

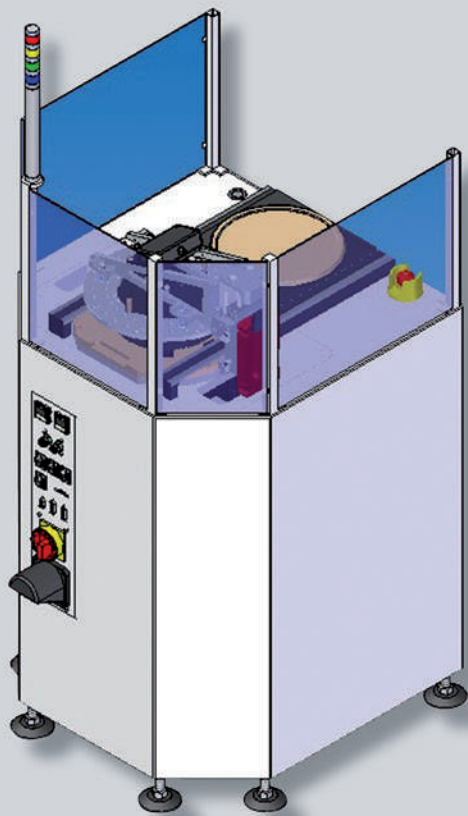
Machine Dimensions: L x W x H: 1440 x 1485 x 2092 mm

Weight: 1.000 kg



## . AUTOMATED CHUCKING SYSTEMS

### STAND-ALONE CHUCKING UNIT SCU 3000

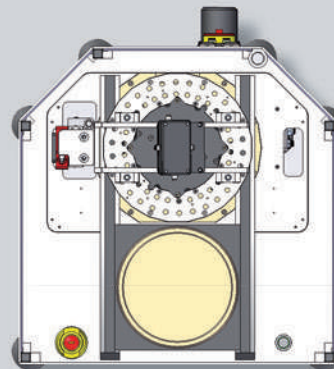
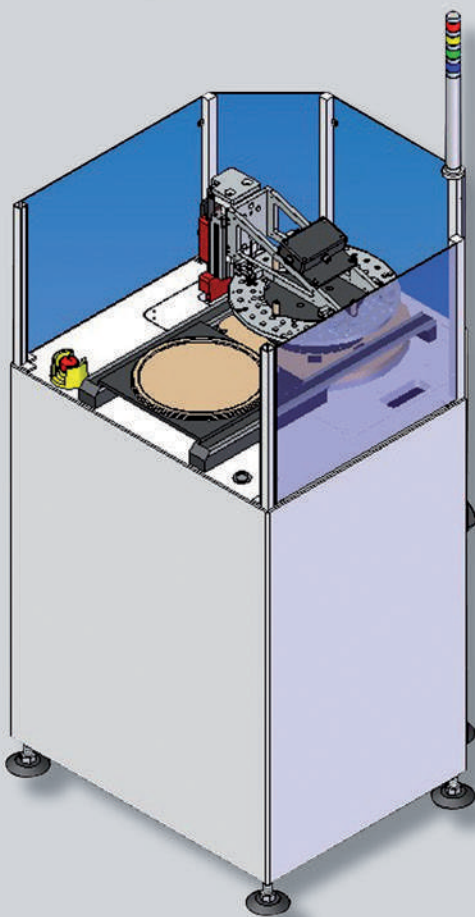


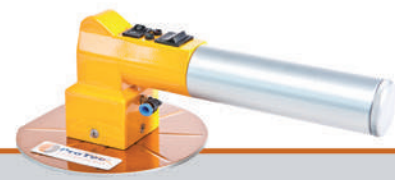
#### Stand-alone semi-automated electrostatic chucking/de-chucking unit:

- Consists of a Chucking Module CM 3000
- Equipped with a stand, a special manual load port, and necessary interfaces, e.g. to access a host system

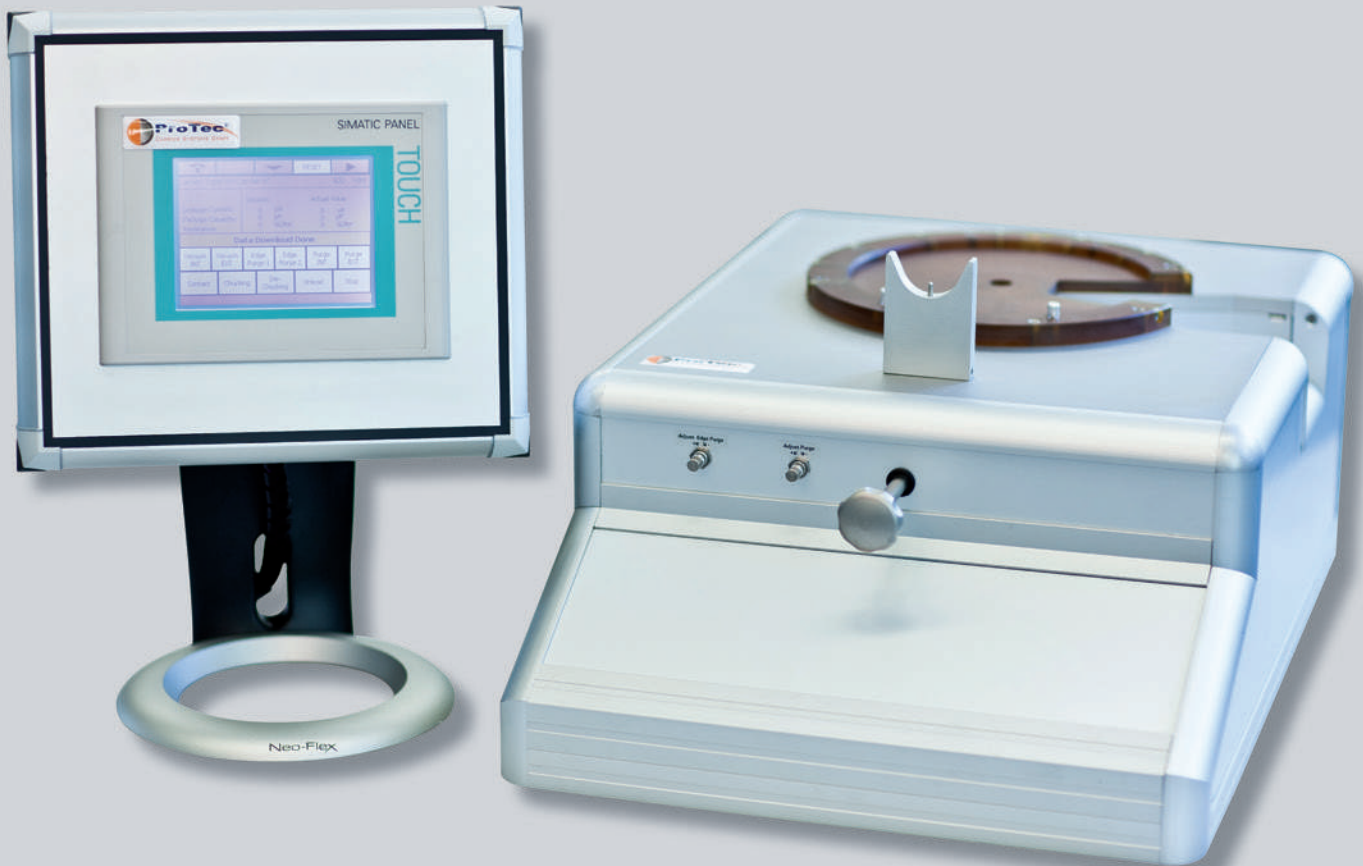
#### Technical Data:

Machine Dimensions: L x W x H: 650 x 700 x 1100 mm  
Weight: 30 kg





## MANUAL CHUCKING UNIT MCU 3000



### Manually operated electrostatic chucking/de-chucking unit

Available in three basic sizes: 4"/6", 6"/8", and 8"/12"

#### Additional Information:

- Working plate on top of the unit determines the substrate/wafer size
- Change of size by replacing working plate to upgrade from 4" to 6", 6" to 8", 8" to 12", or to downgrade from 6" to 4", 8" to 6", 12" to 8"
- Chucking voltage is programmable up to 3 kV
- Enhanced SIEMENS PLC S7/200 controller contains the GUI and several (self-)diagnostic features
- LCD touch-screen panel includes selectable screen display for voltage, current, and status information, customer's chucking type settings and process conditions, etc.
- Parameter configuration settings are stored in customized data records for each carrier type

#### Technical Data:

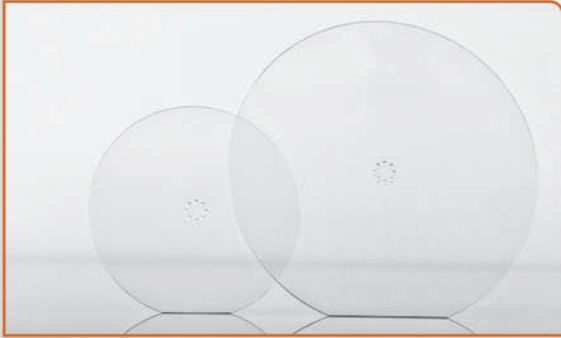
Process Media:	Power supply N <sub>2</sub> (CDA/compressed air) Vacuum
Machine Dimensions:	L x W x H: 621 x 430 x 330 mm
Weight:	12,5 kg
Size:	4", 6", 8", 12", customized solutions, e.g. square-shaped solar cells, 156 x 156 mm





## . SEPARATE COMPONENTS (ACCESSORIES FOR MCU 3000)

### ADJUSTMENT SAMPLE



#### Setting tool:

- Supports a substrate/wafer position
- Alignment for optimal contact by needles
- Indispensable for all handling on MCU 3000 in managing the "Daily Check"

### SIDE TABLE



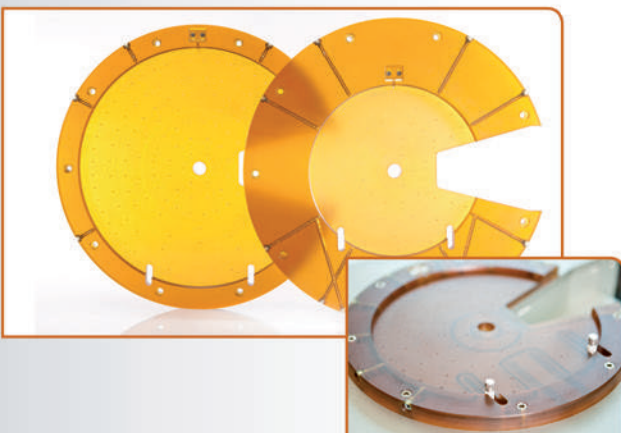
#### Manual alignment tool:

- Supports the pre-centering of a substrate/wafer before it is picked up with the appropriate racket and subsequent transport and is placed on a carrier (T-ESC®)
- Serves as a "clipboard" for substrates/wafer, carrier, or already chucked carrier-wafer package

#### Additional Information:

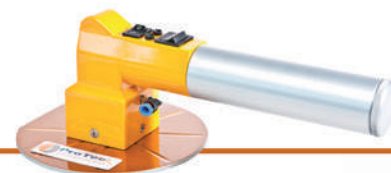
The transfer of substrates or wafers onto the Side Table can also be performed with a pair of tweezers or vacuum tweezers.

### WORKING PLATE



#### Operational/functional disk:

- On which the actual process of chucking takes place, i.e. the thin or ultra-thin substrate/wafer is fixed or removed on a carrier (T-ESC®) by means of electrostatic clamping force
- Enables up- or downgrades to another size:
  - upgrade from 4" to 6", 6" to 8", 8" to 12"
  - downgrade from 6" to 4", 8" to 6", 12" to 8"
- Easy mounting by customer



### RACKET UNIPOLAR

#### General Information:

- Vacuum must be switched on for clamping a substrate/wafer and switched off for releasing it
- De-chucking can also be performed by backside purge
- During handling, substrates/wafers are protected through the whole racket surface area
- Flat/Notch marker supports manual pre-alignment

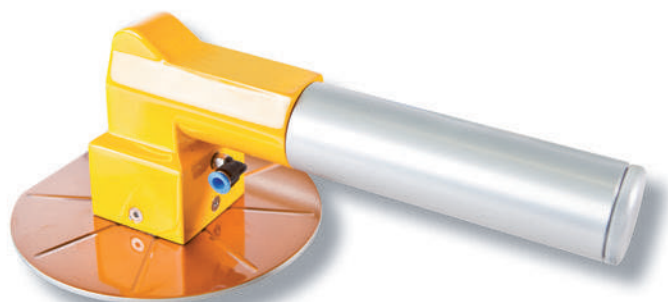
#### Technical Data:

Process Media: Compressed air  
Vacuum

Sizes: 4", 6", 8", 12", customized solutions,  
e.g. square-shaped solar cells, 156 x 156 mm



### STANDARD RACKET

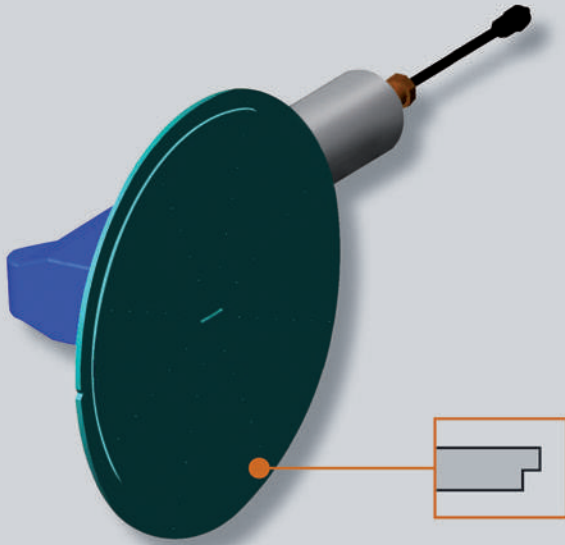


- Standard unipolar racket for handling thin and ultra-thin substrates/wafers and for charging a unipolar T-ESC®
- Essential for charging a unipolar carrier (T-ESC®) at the Manual Chucking Unit MCU 3000



## . RACKET UNIPOLAR

### TAICO RACKET

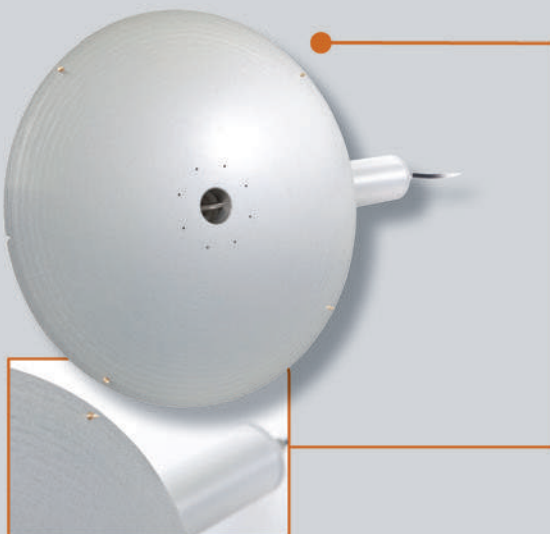


- Capable of clamping a Taico-shaped substrate/wafer by means of vacuum and transporting or transferring it onto a unipolar carrier (T-ESC®)
- Contacts a Taico substrate/wafer during chucking onto a unipolar carrier by touching the cavity in the whole Taico substrate/wafer area

#### **Additional Information:**

The design facilitates good contact to the Taico wafer bottom and provides excellent protection for the whole Taico substrate/wafer surface during handling.

### EDGE RACKET



Design 1

#### **Two designs are available:**

#### **Design 1: Edge Racket with needles**

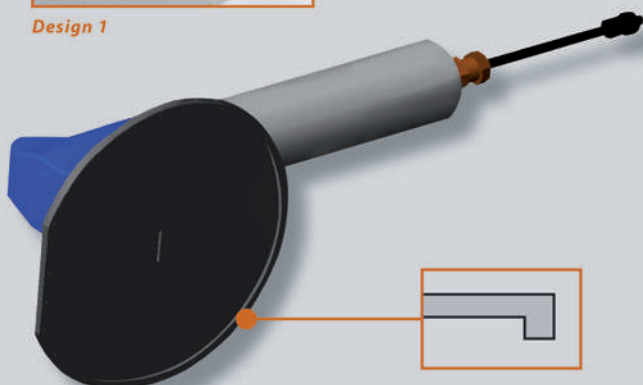
Contacting tool with minimum contact area. During chucking/de-chucking, the substrate/wafer is touched at the edge by 4 contact needles only.

#### **Additional Information:**

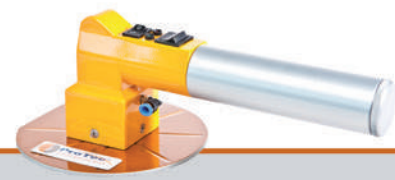
This design is useful when the substrate has a non-conductive coating, e.g. photoresist. Only 4 small openings are needed to achieve unipolar contact.

#### **Design 2: Edge Racket with annulus**

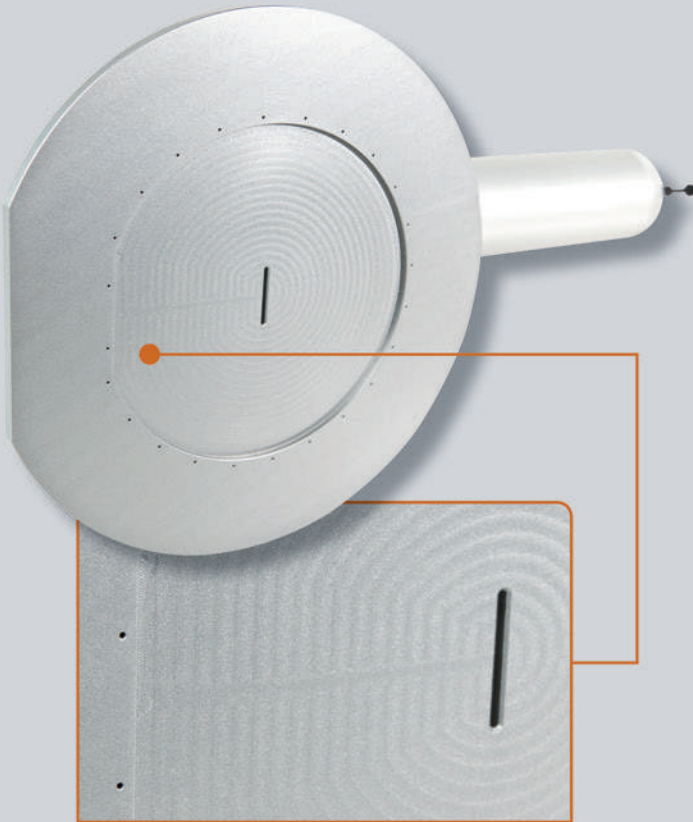
Handling and contacting tool with minimum contact area that contacts the substrate/wafer only in the standard edge area (~4,0 mm).



Design 2



### ADAPTER EDGE RACKET



Special unipolar racket, similar to the Edge Racket with annulus, conceived to handle a substrate/wafer of smaller size in combination with a unipolar carrier of larger size, e.g. wafer 6" on carrier 8" (adapter function).

**Additional Information:**

Purpose is to process smaller wafers in systems or tools of larger size (bridging tool). In order to center the smaller substrate in the carrier, the Adapter Side Table is essential.

**Technical Data:**

Sizes: 4" to 6", 6" to 8", 8" to 12",  
customized solutions

### ADAPTER SIDE TABLE



- Essential manual alignment tool for using the Adapter Edge Racket in combination with different-sized wafers and carriers
- Helps to center a substrate/wafer of smaller size before being clamped by the Adapter Edge Racket
- In a subsequent step, the Adapter Edge Racket transports the smaller-sized substrate/wafer (e.g. 6") and positions it centrally onto a larger-sized carrier (e.g. 8") which had already been placed on the MCU 3000 working plate

**Additional Information:**

Optionally, substrates/wafers can also be placed onto the Adapter Side Table with a pair of tweezers or vacuum tweezers.

**Technical Data:**

Sizes: 4" to 6", 6" to 8", 8" to 12",  
customized solutions

Process Media: Compressed air

## . RACKET BIPOLAR

### RACKET BIPOLAR

The Bipolar Racket is a multifunctional handling tool, employable for various applications. It enables safe and comfortable handling of thin and ultra-thin substrates/wafers using electrostatic force, for example transportation of wafers onto carriers for chucking, microscopic analysis of substrates, de-taping, as well as optical surface inspection. The holohedral clamping of the substrates or wafers guarantees secure and damage-free transport.



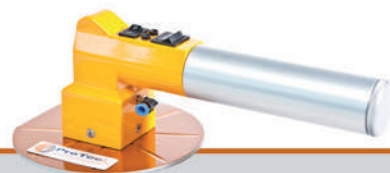
#### Mobile electrostatic handling tool:

- Generates electrostatic force for clamping, transporting, and chucking thin and ultra-thin substrates
- Powered by an integrated battery for wireless and tubeless handling
- Easy one-hand tool operated with a single switch
- Chucking/De-chucking is supported by vacuum/purge
- Flat/Notch marker supports manual pre-alignment

#### Technical Data:

Process Media:	Power supply 9V battery
Optional Media:	Compressed air Vacuum
Sizes:	4", 6", 8", 12", customized solutions, e.g. square-shaped solar cells, 156 x 156 mm





## MEDIA TEST KIT



**Special measurement tool for:**

- Measuring pressure and flow (N<sub>2</sub> or CDA, vacuum)
- Ensuring that appropriate media are available in advance of the chucking process

**Technical Data:**

Process Media: Power supply 230 V  
 Machine Dimensions: L x W x H: 290 x 220 x 75 mm  
 Weight: 3,0 kg

## MEDIA BOX



**Media tool:**

- Designed to supply a bipolar racket with purge **or** vacuum without presence of vacuum from MCU 3000
- Generates adjustable purge or vacuum from compressed media

**Technical Data:**

Process Media: Compressed air as well as N<sub>2</sub> or CDA  
 Dimensions: L x W x H: 135 x 80 x 110 mm  
 Weight: 0,75 kg



## **ProTec Carrier Systems GmbH**

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PO Box 22 35 27  
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