

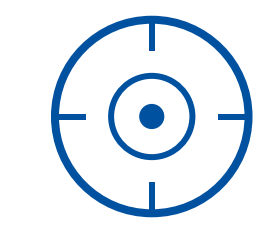
MagLev Platforms and Active Wafer Chuck Technology for Advanced Semiconductor Manufacturing

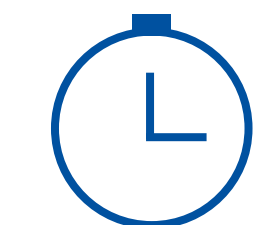
Abstract

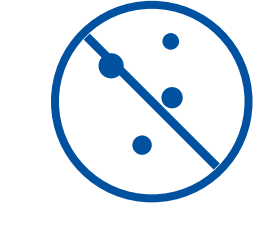
Advanced semiconductor manufacturing and inspection technologies increasingly demand higher positioning accuracy, throughput, cleanliness, and process stability. Emerging advanced packaging technologies such as hybrid bonding place stringent requirements on both motion-system performance and wafer topography, impacting bonding processes and the inspection and metrology tools needed to characterize them. MagLev platforms offer a contact-free approach to wafer transport, precision positioning, force control, and high-speed scanning, enabling simplified system architectures and improved performance. Complementing these motion technologies, Active Wafer Chuck systems based on piezoelectric actuation compensate wafer bow, warp, and local deformation directly at the substrate interface. Together, these approaches address key challenges in next-generation semiconductor equipment and advanced packaging applications.

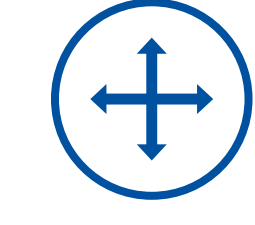
MagLev Motion Platform

Challenge

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Precision Over Full Travel
Bonding, inspection, and metrology require precise positioning across the entire substrate, not just at a single working point.
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Throughput and Dynamics
Tool output is limited by move-and-settle time – not just peak speed. Added mass and compliance further stretch settling times.
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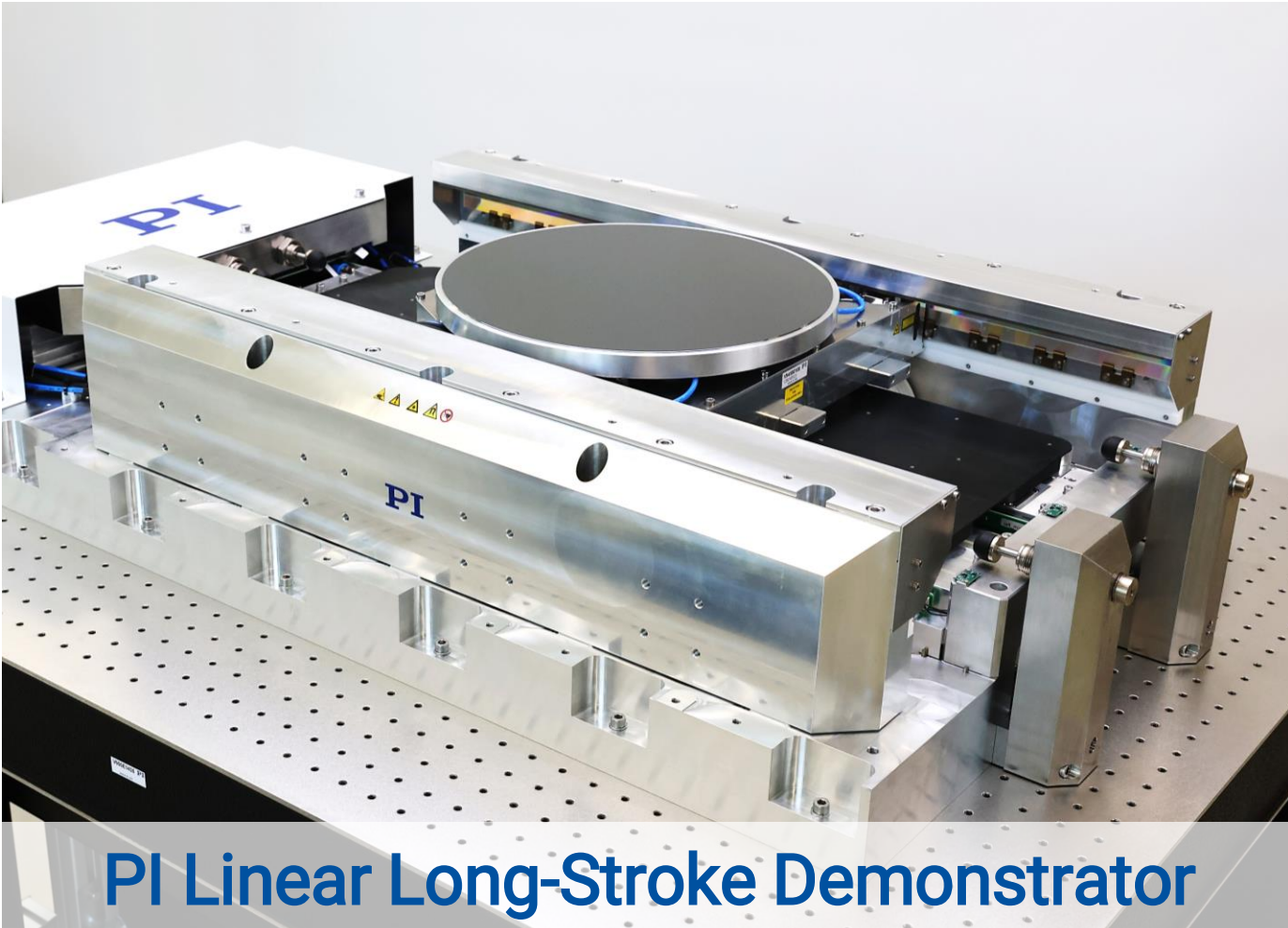
Cleanliness
Guides, bearings, and lubricants generate particles requiring airflow in applications where cleanliness is critical.
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Multi-Axis Process Control
Alignment, leveling, focus and controlled contact force are required simultaneously in several degrees of freedom.

Solution

- One Stage for Long Stroke and Fine Motion**
Contact-free levitation enables precise long-range linear or rotary motion, eliminating mechanical guides while achieving piezo-like accuracy across the entire stroke.
- High Force Density, Low Moving Mass**
Direct actuation and low moving mass deliver high acceleration, short settling, and ripple-free continuous scanning across the full stroke.
- No Contact, No Lubricants, No Wear**
With contact-free bearing and actuation, no particles or airflow are generated eliminating mechanical disturbances.
- Intrinsic 6DOF Controllability**
High-performance, coupled or decoupled control over position, force and torque in all six degrees of freedom — with one compact mover.

Performance & Values



Parameter	Linear Stage	Rotary Stage
Long Stroke	400 mm (X)	unlimited (C)
Dynamics*	Acceleration X: 2 ... 6 g	Velocity: >600 rpm
Payload	> 2 kg	> 2 kg
Stability* X, Y, Z	< 2 nm	< 3 nm
Stability* $\theta X, \theta Y, \theta Z$	< 20 nrad	< 50 nrad
Aux. Stroke*	Y,Z: $\pm 200 \mu\text{m}$ $\theta X, \theta Y$: $\pm 0.5 \text{ mrad}$ θZ : $\pm 1 \text{ mrad}$	XY,Z: $\pm 200 \mu\text{m}$ $\theta X, \theta Y$: $\pm 0.25 \text{ mrad}$

One Stage

Long-range travel, nanometer positioning, and force control in one contact-free body.

6DOF at Full Speed

Focus, tip/tilt, and force control on each axis, while in motion.

New Machine Concepts

Fewer interfaces, less commissioning effort, more parallel motion and process functionality.

Active Wafer Chuck / Surface Shaping

Challenge

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Warpage
Bent or warped substrates, such as wafers, create challenges during chucking as well as throughout measurement and production processes.
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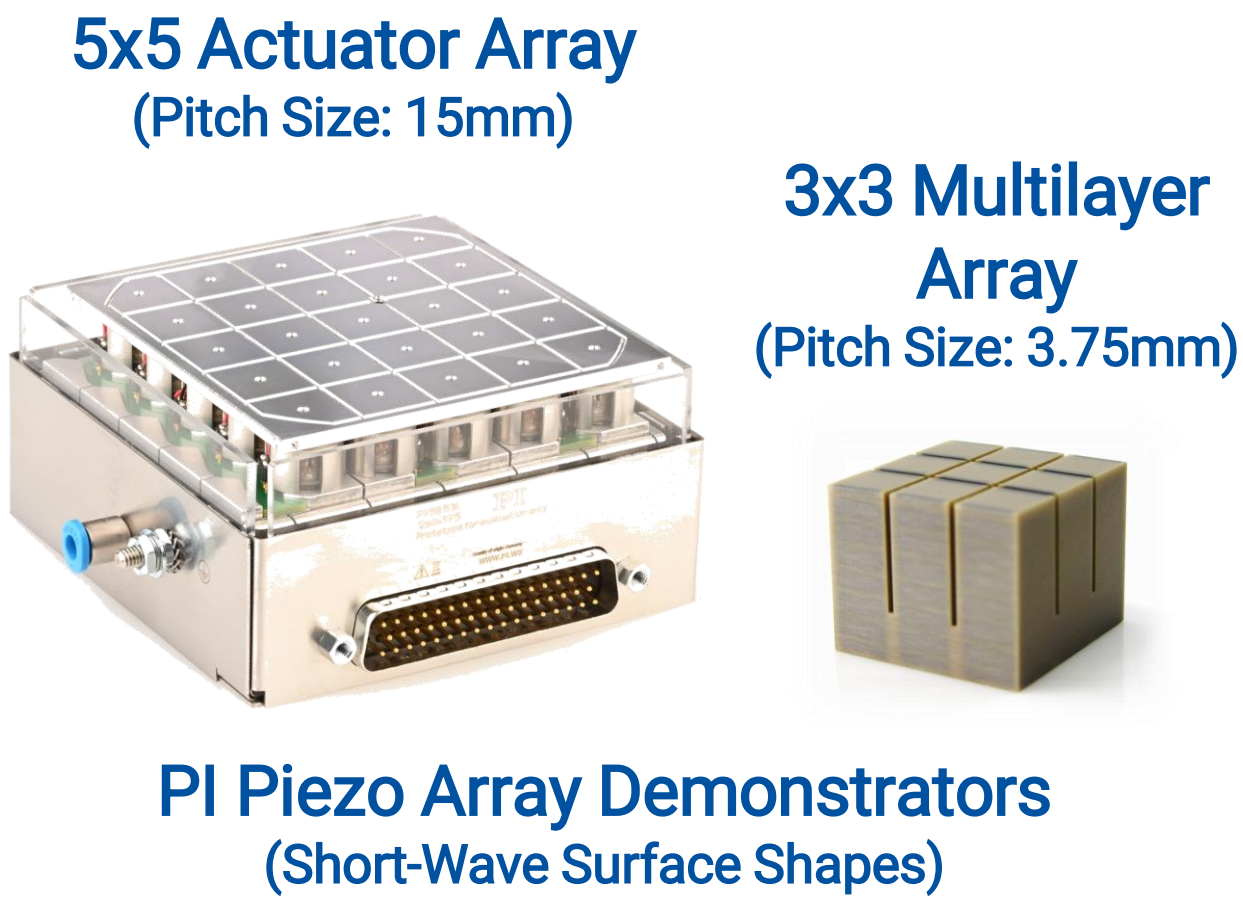
Varying Stroke and Resolution
Different applications demand different specifications for shape-control.
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Specimen Integrity Risk
Curvature concentrated at kink edges can risk specimen damage, while chucking at individual points can lead to unintended tent-like deformation.

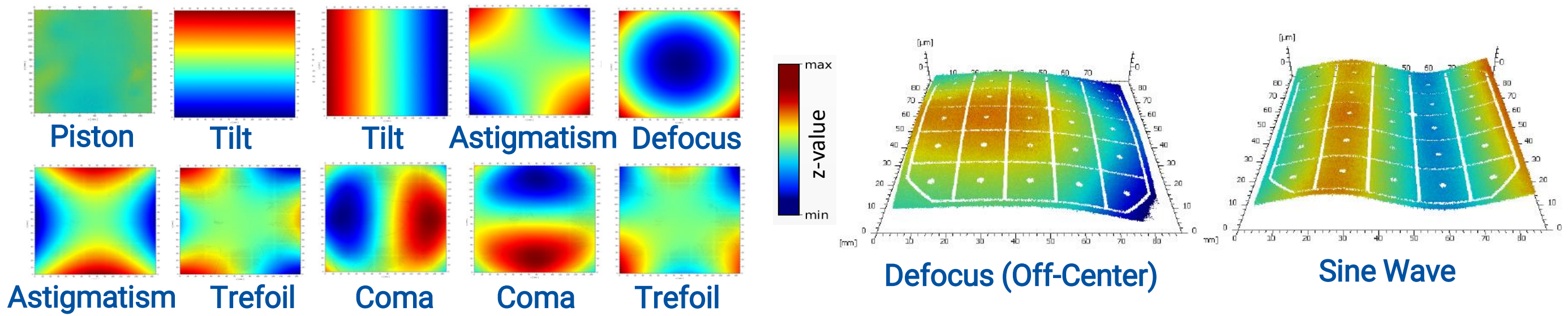
Solution

- Active Shape Control**
Use of an actively deformable chuck ensures reliable chucking while enabling dynamic adaptation of the substrate shape throughout the process.
- Appropriate Amplitude and Pitch**
Depending on the application requirements, the solution can provide long- or short-wavelength deformation, or a combination of both.
- Smooth Shape Gradients**
A stiff support structure ensures smooth shape gradients with high-resolution, highly repeatable piezo actuators delivering the required deformation forces.

Performance & Values



Surface Measurement Results:



Parameter	Active Wafer Chuck	Piezo Arrays
Number DOFs	10 (Zernike Modes up to 3 rd Order)	Selectable
Stroke: (Active Operation)	Rigid Body Motion: up to $\pm 150 \mu\text{m}$ ** Deformation Modes: up to $\pm 100 \mu\text{m}$ **	Actuator Array: $\pm 3 \mu\text{m}$ Multilayer Array: $\pm 1.5 \mu\text{m}$
Minimal Increment Motion (Closed Loop)*	< 15 nm	-
1 st Resonant Frequency	> 350 Hz	-

* Preliminary specifications ** More strokes available upon request

Flexible Shapes

Superposition of Zernike modes maps complex and rotatable surface shapes.

Flexible System Sizes

Solutions ranging from entire wafers to arrays just a few millimeters in size — with larger strokes available upon request.

Set and Forget

Semi-active (PIRest) operations enable optimized stability and power consumption.

Conclusion

MagLev systems are tailored to the specific application for optimal performance. Stroke, dynamics, and degrees of freedom follow the process — not a fixed axis stack. Instead, linear, rotary, or potentially planar motion is enabled by a single contact-free platform.

Active wafer shaping corrects what motion alone cannot. Controlled long- and short-wavelength deformation addresses distortion of varying sizes and shapes directly at its source — the wafer itself.

LEVITATE. MOVE. SHAPE.
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LET'S TALK.
Tell us your process. We'll tailor the motion system.