

Gel-Pak®

Bio-inspired Textured Carrier for IC Handling

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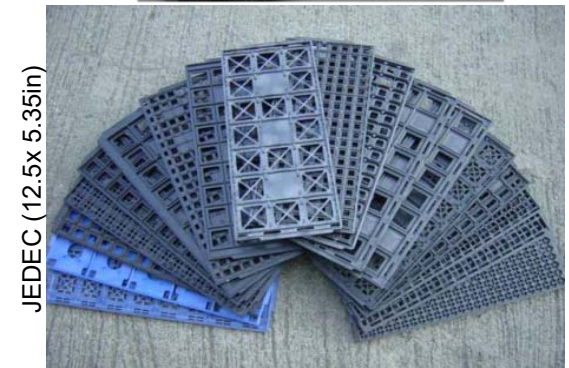
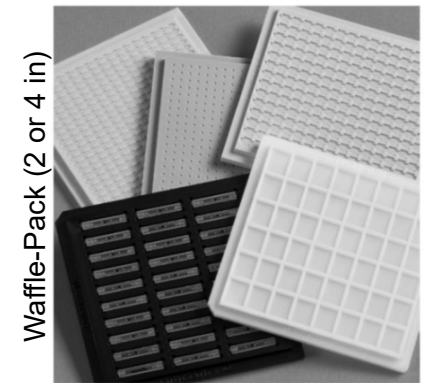
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Overview

- Brief overview of IC handling trays
- Reasons for bio-inspired solutions
- Gel-Pak development
- Compared to existing carrier trays
- Summary

IC Carrier Trays

- Multiple handling steps between wafer-to-substrate
- Handling options between processes
 - **Trays**, Tape & Reel and others
- Pocket size specific to IC dimensions
 - >2000 different pocket dimensions exist
 - Standards developed in the 80's
- Yield issues
 - Damage from free movement within pocket
 - Small ICs can escape or flip during transport
 - Susceptible to jumping out of an open package subject to small vibrations, static charge or strong airflow
- Limitations
 - Edge collet pickup

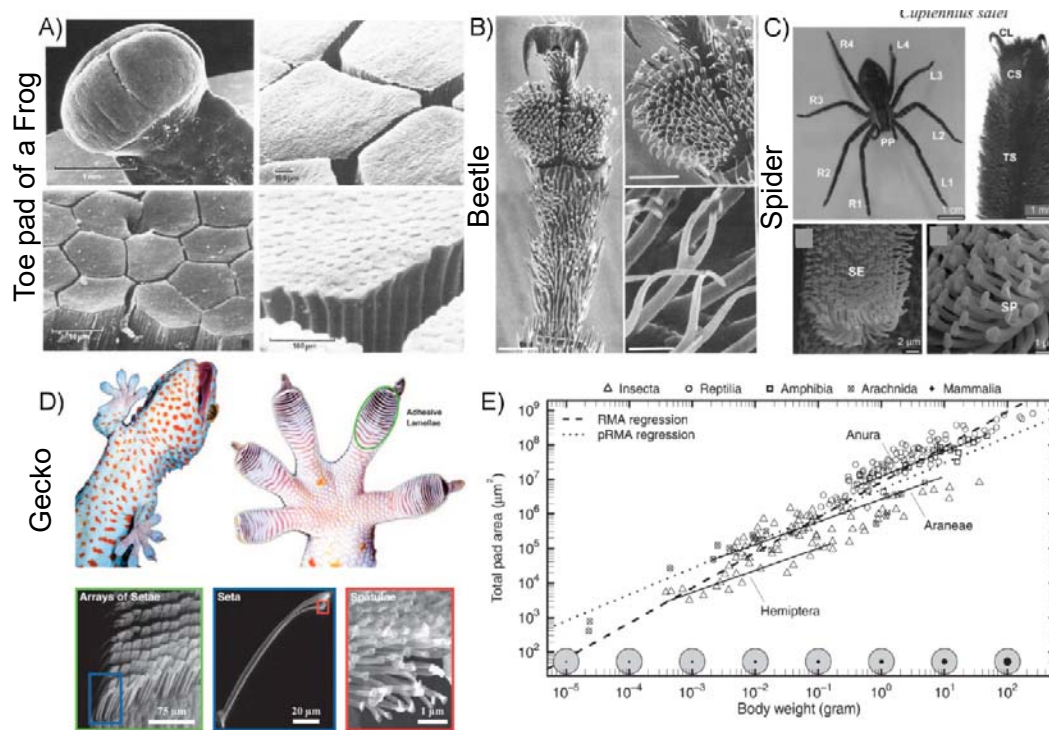


IC Carrier Requirements

- Immobilize during Shipping & Handling (S&H)
- Stress free placing and picking
- Residue & damage free IC delivery
- Accommodate changing die dimensions
- Compatible with existing PnP and SMT machines
- Reusable
- Meet UPH targets

Adequate adhesion but easy release
similar to a
Dry Adhesive

Bio Adhesives



A Review of the State of Dry Adhesives: Biomimetic Structures and the Alternative Designs They Inspire
J. Eisenhaure and S. Kim; University of Illinois, *Micromachines* 2017, 8, 125

Learnings

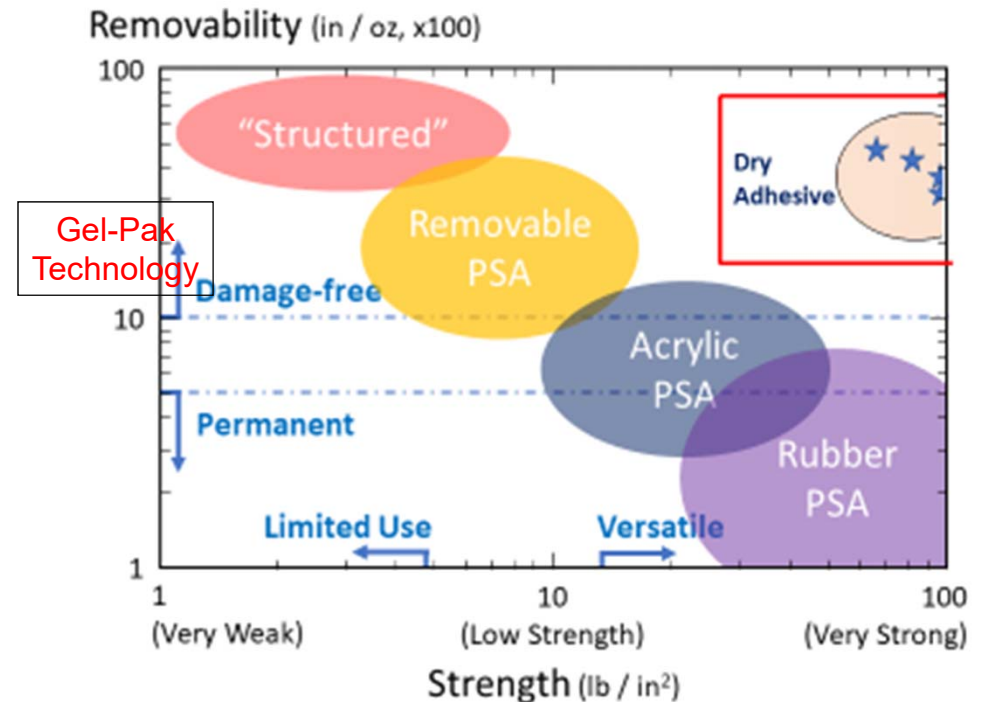
- Holding relied on a textured pads & **contact area** proportional to body weight
- Holding & release is a combination of specialized **adhesive** systems and surface **texture**
 - Viscoelasticity and mechanical interlocking
- A **dry adhesive** system that has **strong holding** but **easy release** by altering texture, contact area & adhesive response

IC Handling Differences Over Others

Bio

- Surface roughness: In nature the surfaces are very rough so fibrils are very soft with long aspect ratio to give its compliance. IC surfaces are not as rough.
- Mass: ICs are low in mass and the holding force to be just enough to survive drop, but easy to pick in an automated PnP process.
- Extreme temperatures: In nature the temperatures are not as extreme.
 - IC S&H ranges from -10C to 50C.
- Fragility: Sensitive to down & pick force.
- High UPH: PnP and SMT arms moving much faster

Commercial Dry Adhesives

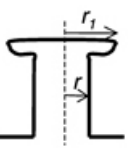
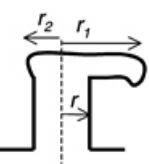




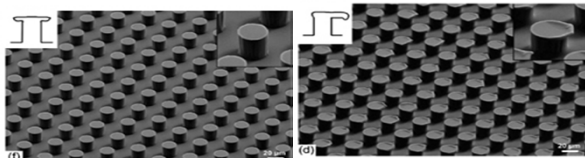
Product Development Criteria

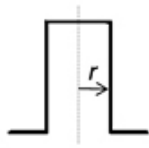
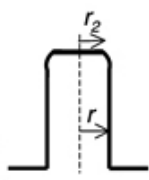
- Effectively immobilize the IC but still easy to pick
- HVM process friendly
 - Molding, extrusion or other HVM fabrication techniques
- Comparable total-cost solution
 - Meet established back-end process cost models
 - Similar process UPH
- Compatible tray form factor
 - Standardized since the 80's

Texture vs. Tack – Published Research

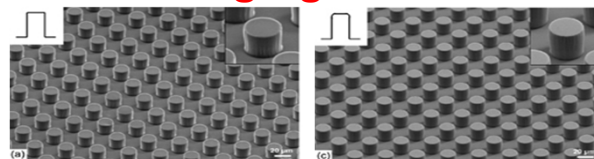
Contact geometry	Pillar radius, r (μm)	Tip dimensions (μm)	E^* (MPa)
Mushroom tip (fabricated by printing) 	10	$r_1 \sim 12.9 \pm 0.3$	$2.50^{(*)}$
	25	$r_1 \sim 32.1 \pm 1.5$	$1.81^{(*)}$
Spatular tip 	10	$r_1 = 11.3$ $r_2 = 10.1$	$2.29^{(*)}$
	25	$r_1 \sim 33.8$ $r_2 \sim 30.1$	$1.81^{(*)}$

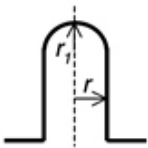
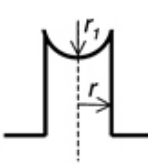
Not HVM Friendly



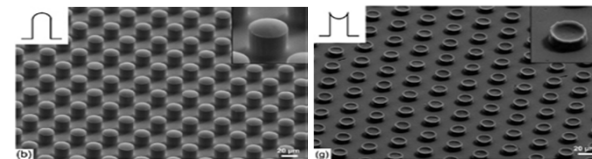
Contact geometry	Pillar radius, r (μm)	Tip dimensions (μm)	E^* (MPa)
Flat tip 	2.5		1.38
	5		1.30
	10		0.95
	25		0.76
Flat tip with rounded edges 	2.5	$r = 2.9$ $r_2 = 2.7$	1.38
	5	$r = 5.2$ $r_2 = 4.8$	1.00
	10	$r = 10.0$ $r_2 = 9.0$	1.16
	25	$r = 25.5$ $r_2 = 21.6$	0.85

Challenging for HVM



Contact geometry	Pillar radius, r (μm)	Tip dimensions (μm)	E^* (MPa)
Spherical tip 	2.5	$r_1 = 9.3$	$1.34^{(*)}$
	5	$r_1 = 16.4$	$1.13^{(*)}$
	10	$r_1 = 24.1$	$1.02^{(*)}$
	25	$r_1 = 39.3$	$0.58^{(*)}$
Concave tip 	5	$r_1 \sim 3$ $h = 9$	0.60
	10	$r_1 \sim 3$ $h = 9$	0.59
	25	$r_1 \sim 6$ $h = 9$	0.50

HVM Viable

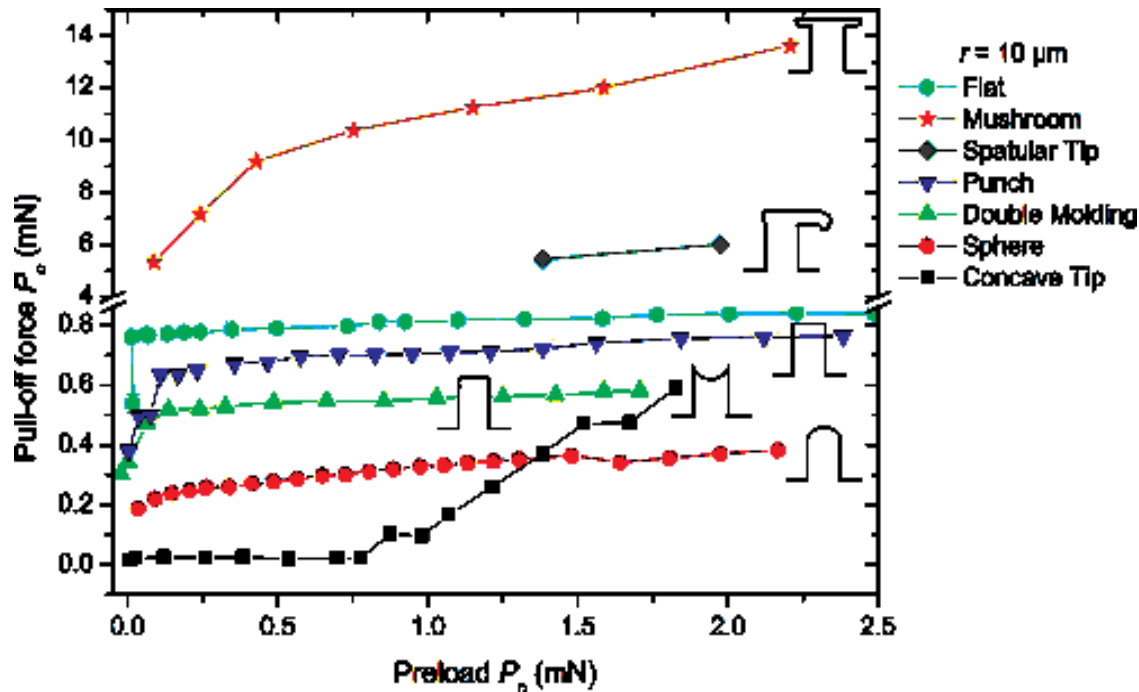


Contact Shape Controls Adhesion of Bioinspired Fibrillar Surfaces,
A. Campo, C. Greiner, E. Arzt, Max Planck Institute for Metals Research; *Langmuir* 2007, 23, 10235-10243

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Tack Force

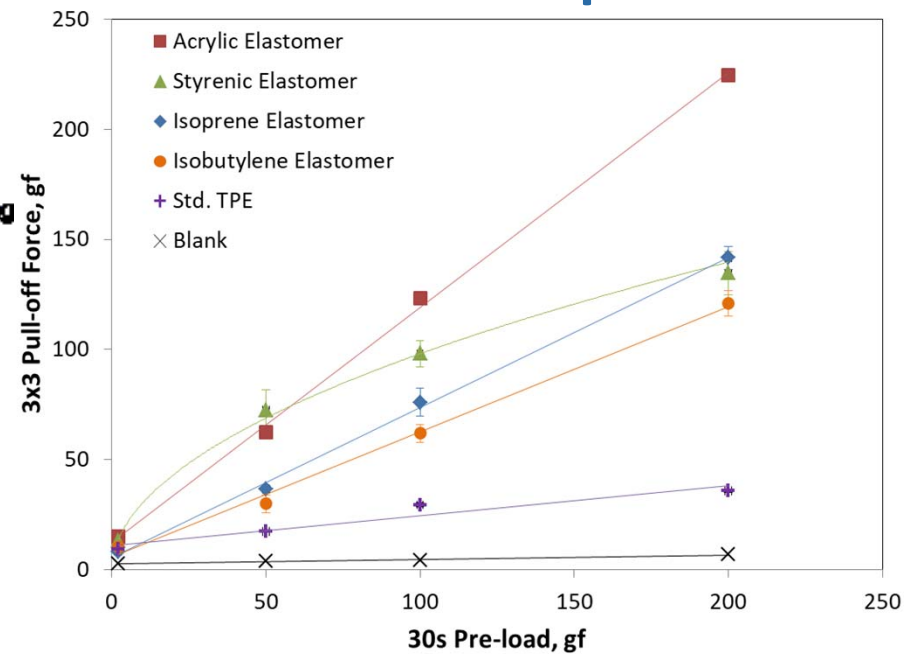
Published Work



6 different Textures, 1 elastomer

Contact Shape Controls Adhesion of Bioinspired Fibrillar Surfaces,
A. Campo, C. Greiner, E Arzt, Max Planck Institute for Metals Research; *Langmuir* 2007, 23, 10235-10243

Gel-Pak Development



1 Texture, 5 different elastomers

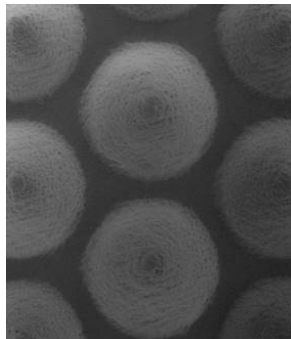
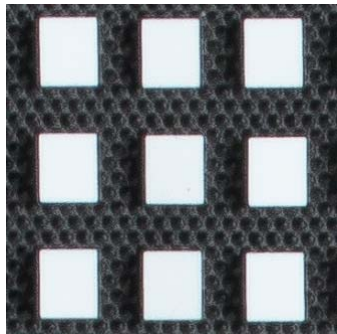
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Challenges During Development

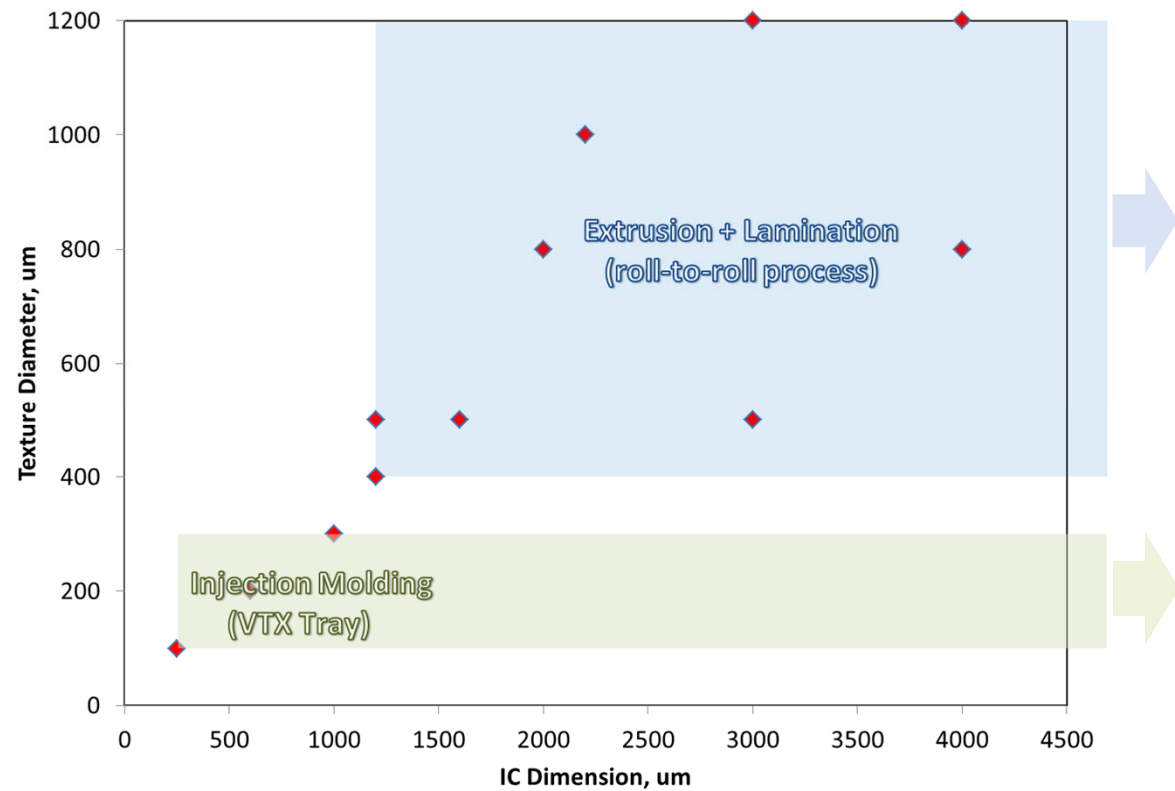
- Surface texturing not in IC handling space
 - Industrial solutions are mostly for ergonomic considerations
- No standard tack metrology exists on textured surfaces
- Process challenges
 - Demolding, roller/mold sticking, texture crushing in roll-to-roll processing
 - Precise texture & tray flatness
- Tuning tack & texture to survive shock & vibration but still easy to pick

Textured VTX Tray

2x2 inch Tray

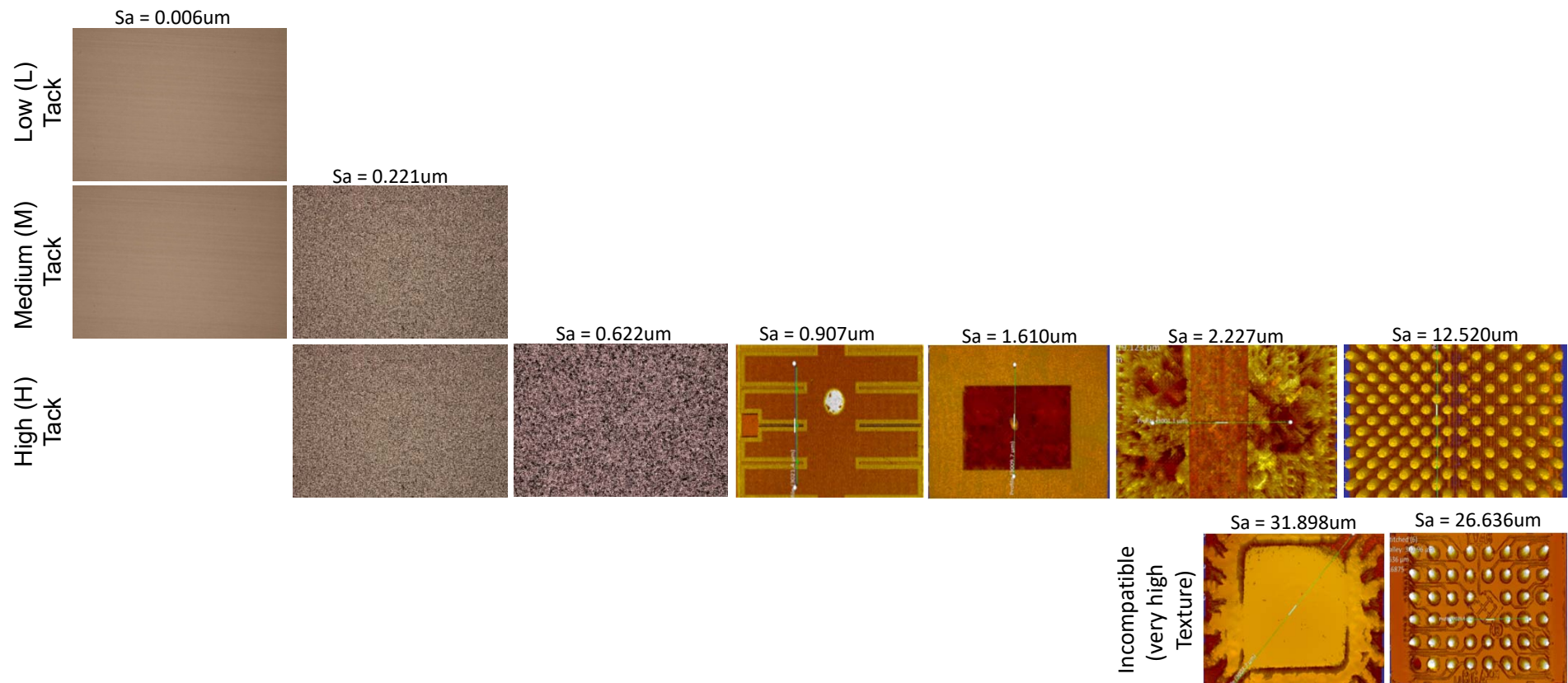


250µm



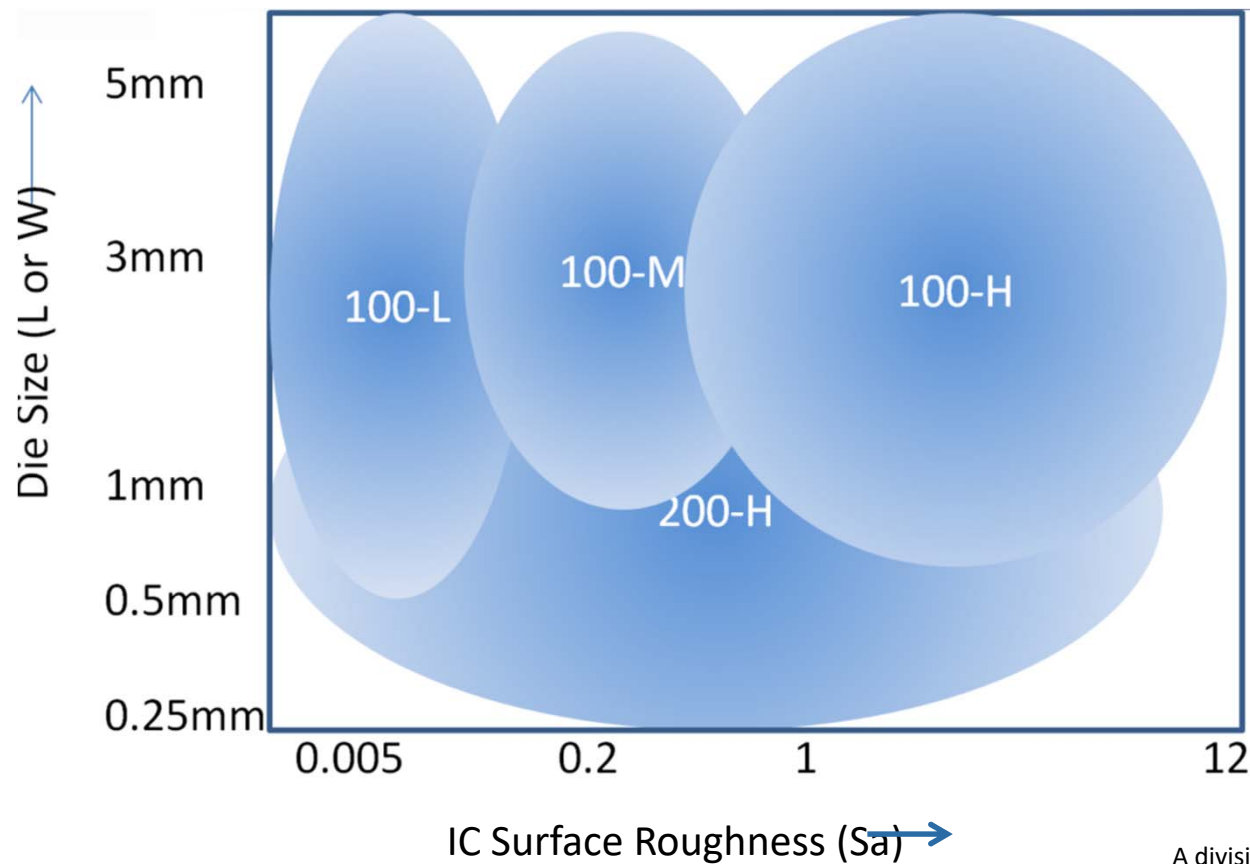


Compatible IC Surface Roughness



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IC Compatibility of VTX Textures/Tack



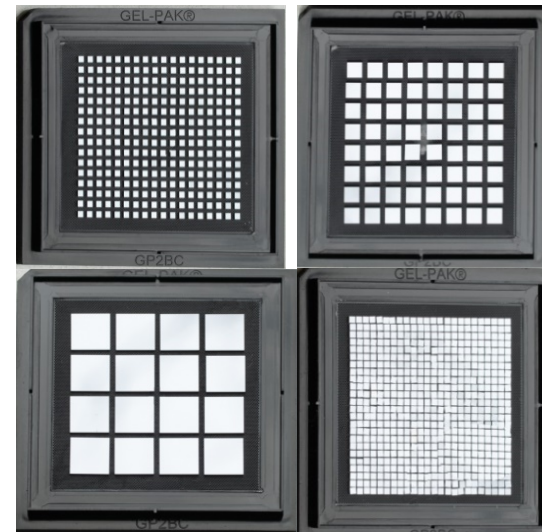
Compared to Waffle Pack

- Good for high SKU complexity
- Damage free shipping and handling
 - Suitable for thin, MEMS, compound semi etc.
- Faster to market
 - No design or tolling time to custom design trays
- Limitations
 - Curved optics
 - not suitable for all bump types and sizes

Waffle-Pack
Single SKU Only



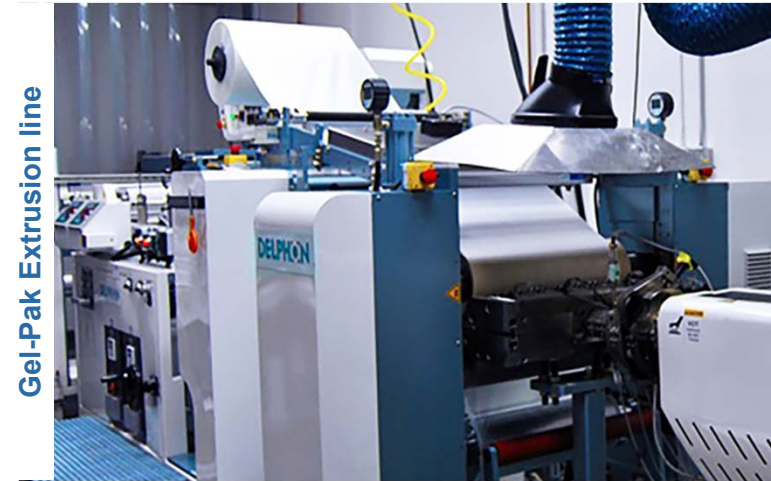
single VTX trays can
handle various IC
chip sizes





Roll-to-Roll Dry Adhesive Film

- Unique processing technology developed for offer roll-to-roll film
- Flexible film that can be laminated onto most rigid surfaces to offer different form factors.
- Compatible with most bare IC. Working on expanding to packaged IC.



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Summary

- Commercially available “Dry” Adhesive technology for a range of IC handling use
- A universal surface format that is not restrictive like commercial molded solutions
- Securely holds the IC during transport but easy to pick
- Customizable from a 2inch tray to a 300mm wafer dimension
- Drop-in solution to existing PnP and SMT machines





Thank You

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