PulseForge Tools
For Temporary Bonding and Debonding Application

April 2024

PulseForge®

PulseForge

Capture light in a bottle to address key industrial needs

Established in 1999

Delivering production level tools since 2006

Semiconductor device manufacturing

Display manufacturing

Wearable electronics

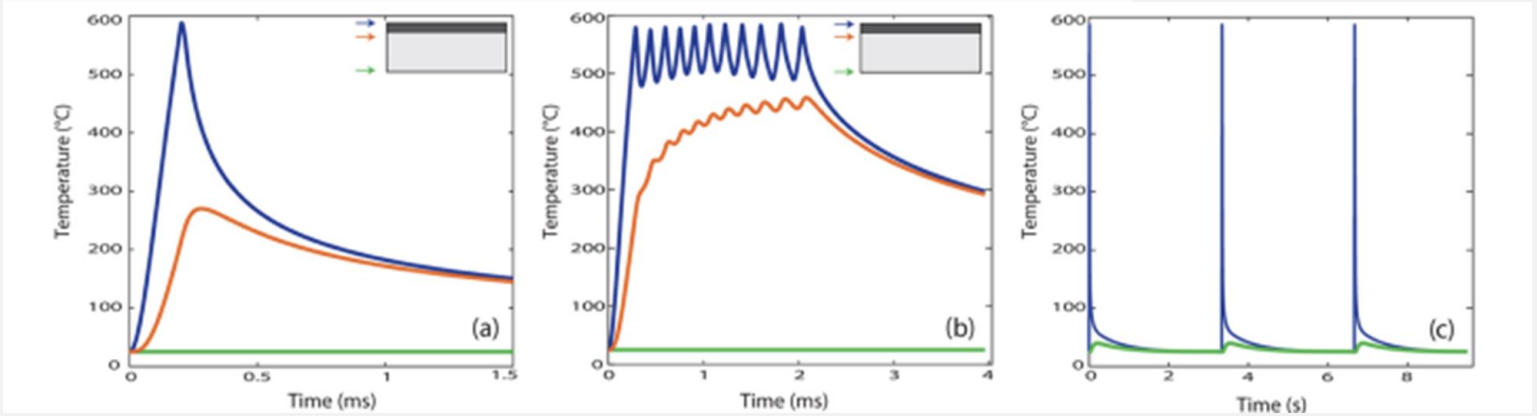
Automotive electronics

Photovoltaics

Internet of things

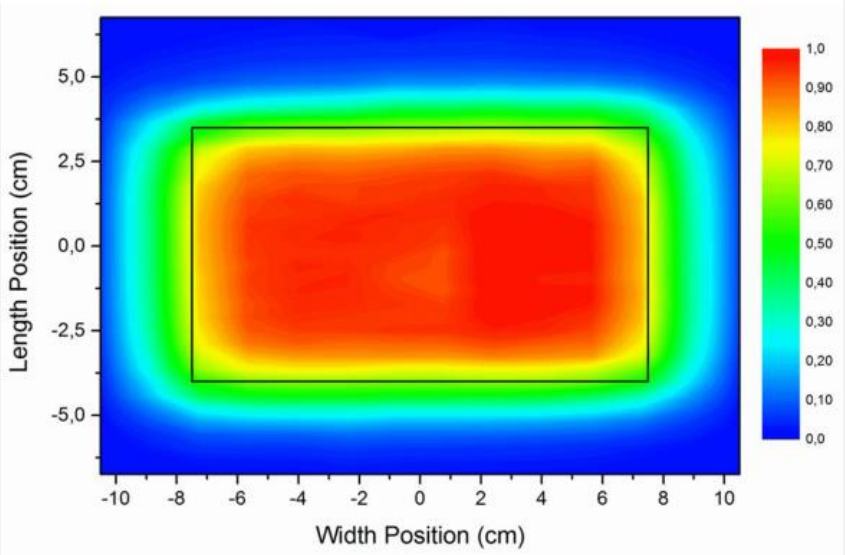
Proprietary Technology Enables Processing in Microseconds

Precise temporal control for light output

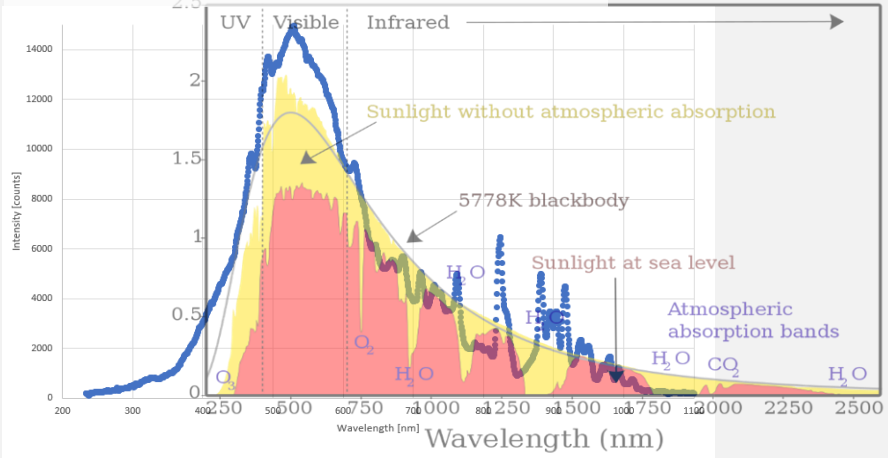


Single pulse | Shaped single pulse | Multiple pulses

Wide area illumination



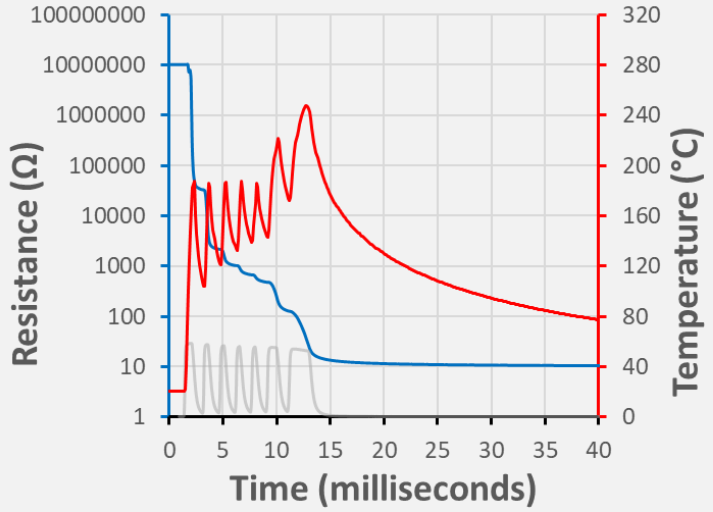
White light illumination



Non-equilibrium processing

Coating

Substrate



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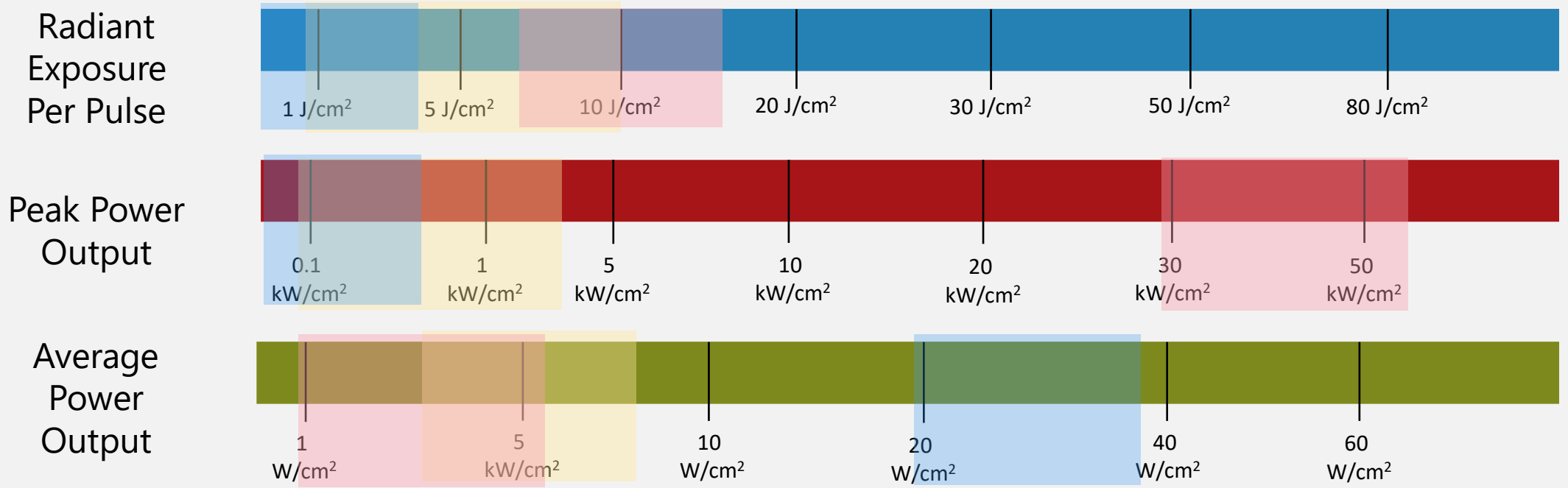
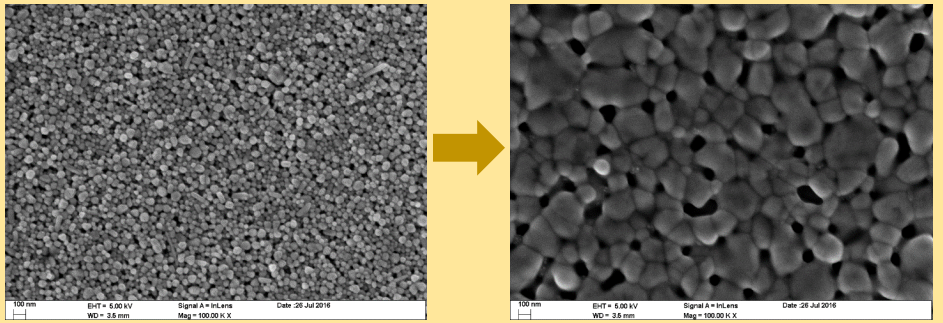
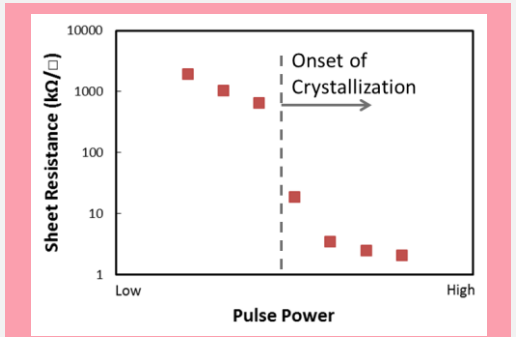
Key Control Parameters





Sintering of Silver Nanocrystals on Plastics



Crystallization of a-Si on Glass

Photonic Soldering

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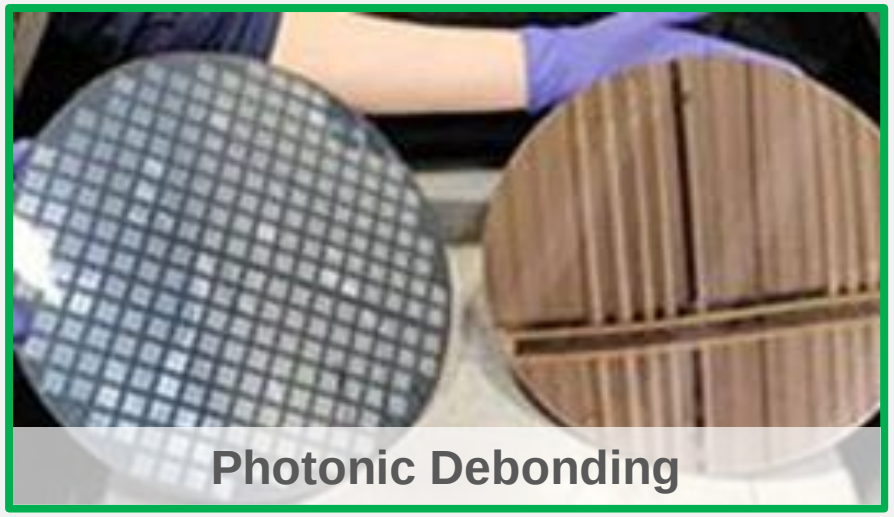
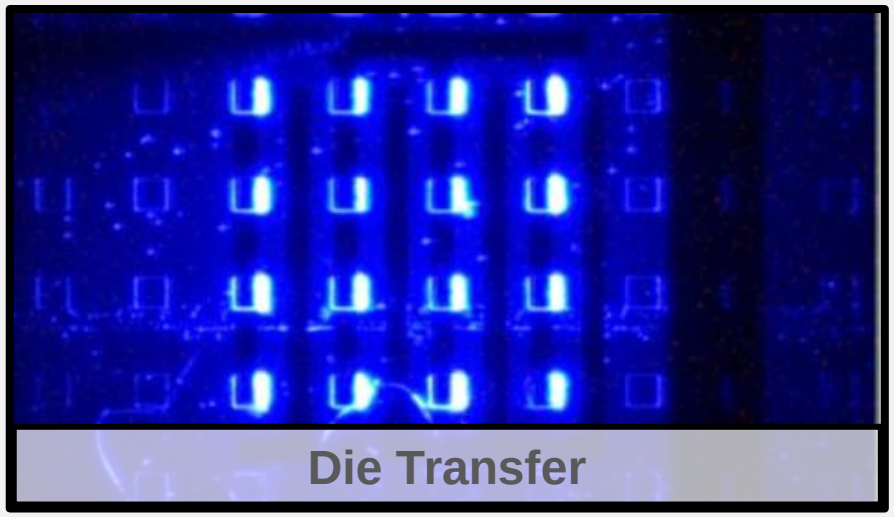
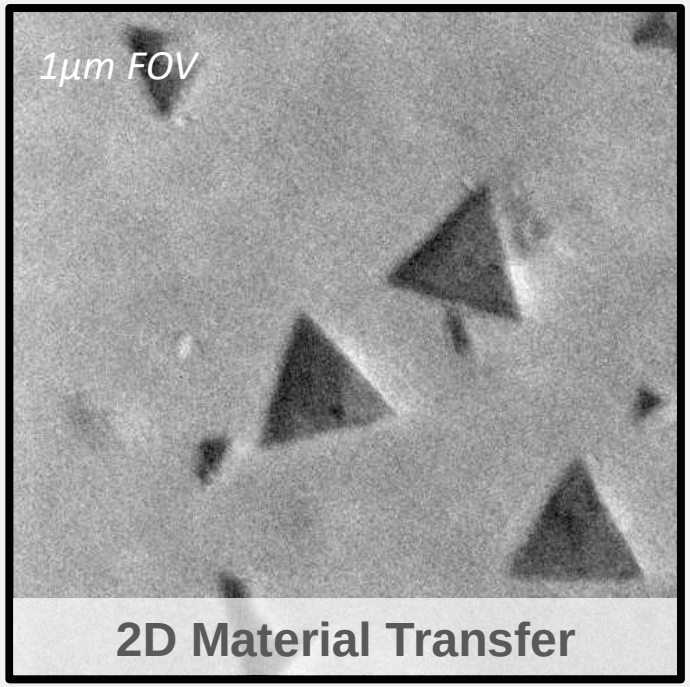
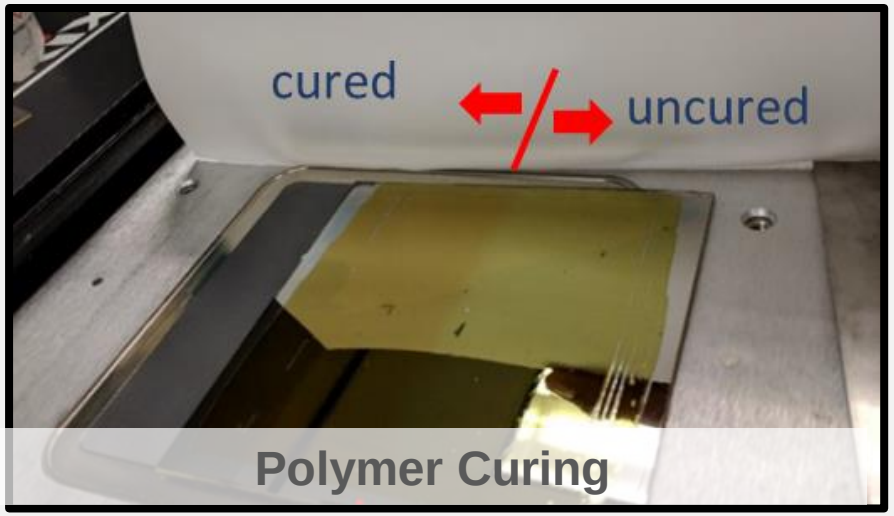
Advances in the Micro-Electronics Industry


Photonic Debonding

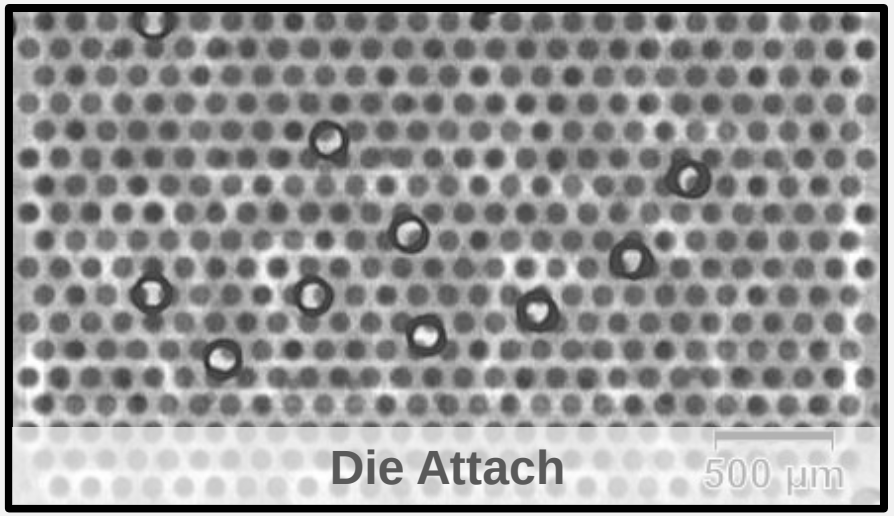

Die Transfer



2D Material Transfer



Polymer Curing



Die Attach

And others…

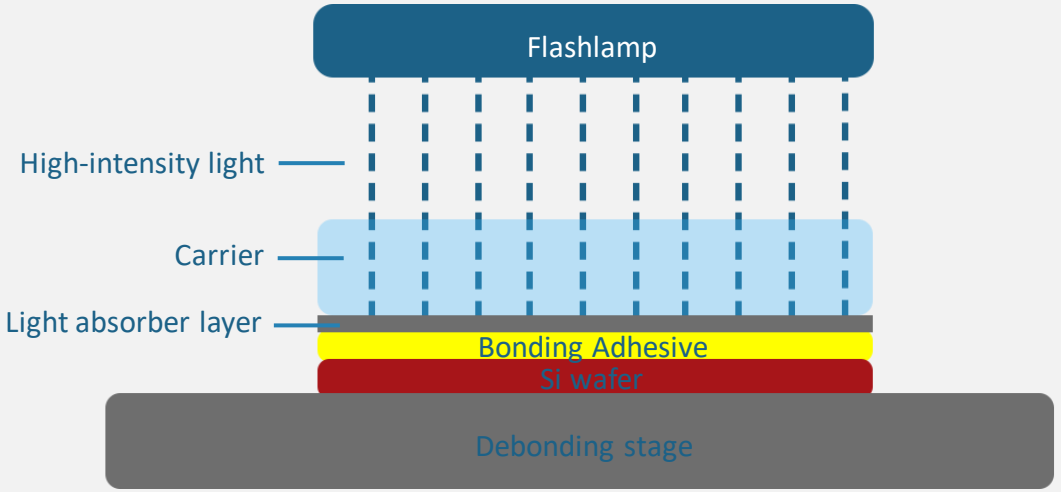
PulseForge®

Photonic Debonding

- Utilizes **production-proven** PulseForge technology
- At least **40% lower processing costs** per wafer compared to laser debond
- Introduction to market in March 2023. Beta customer evaluation started in early 2022.
- **Strategic partnerships** with several semiconductor equipment providers to provide high-volume manufacturing tools
- **Global customer engagement** – IDMs and OSATs (HBM, IGBT, SiC power device, advanced packaging including panel-level)
- **Double-digit** tool bookings

Photonic Debonding – Value Proposition

Adding value to existing TB/DB processes with cost-effective, lower thermal stress and no-residue debonding



- **Zero force** separation
- Lower processing cost per wafer by **at least 40%** compared to laser debond
- Cleaner debonding process – **Low residue** simplifies cleaning efforts significantly
- Improved throughput **(> 60 WPH)**
- **High Yield**
- **Reusable carriers** with inorganic light absorber layer (LAL)
- Inorganic LAL supports **high temperature device fabrication** (up to 450°C) – Leading to improved device performance

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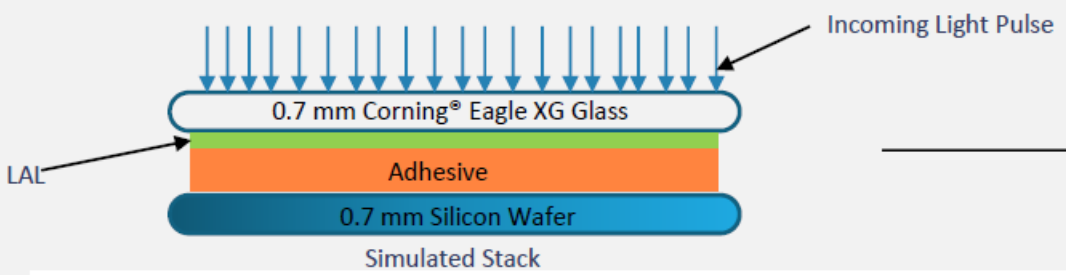
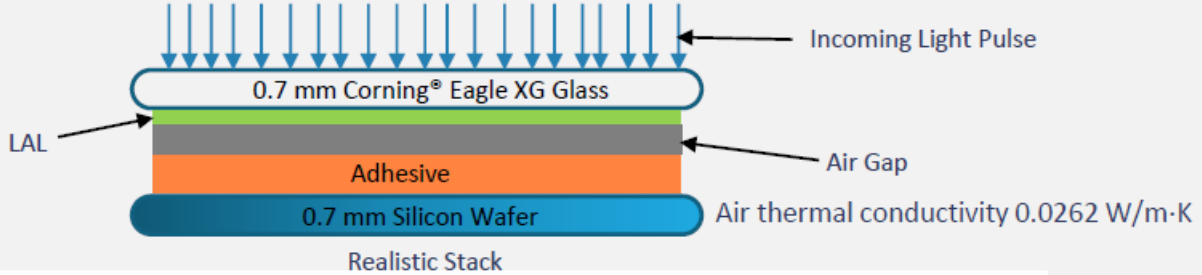
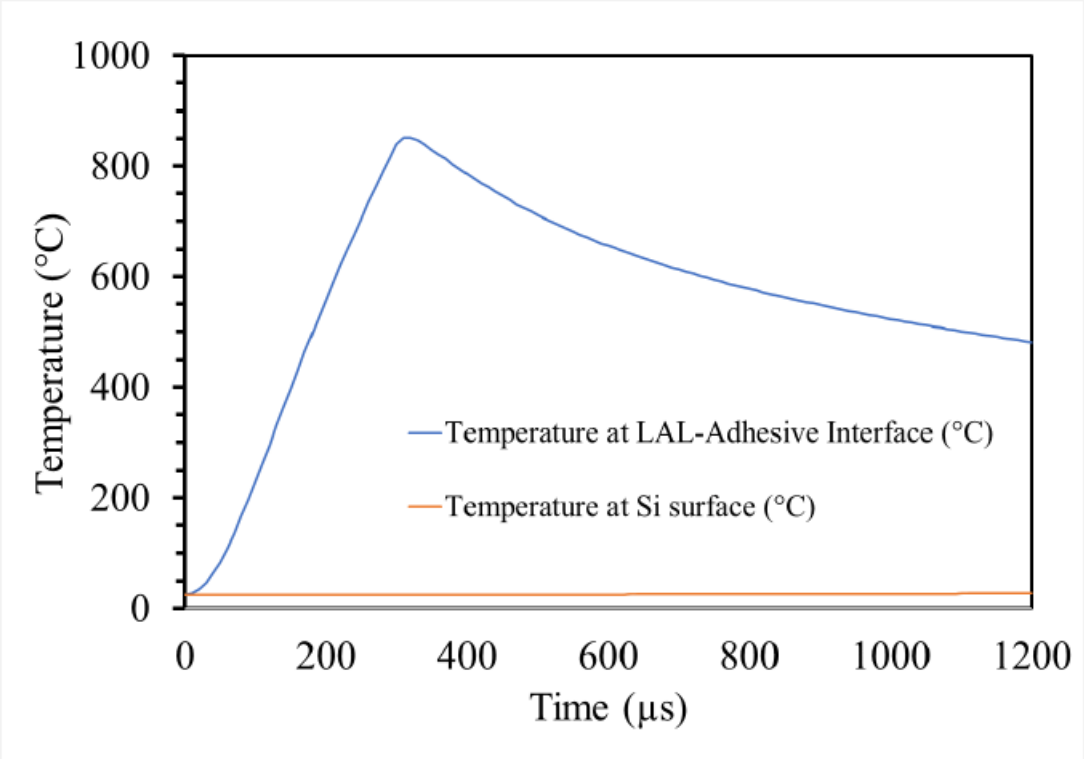
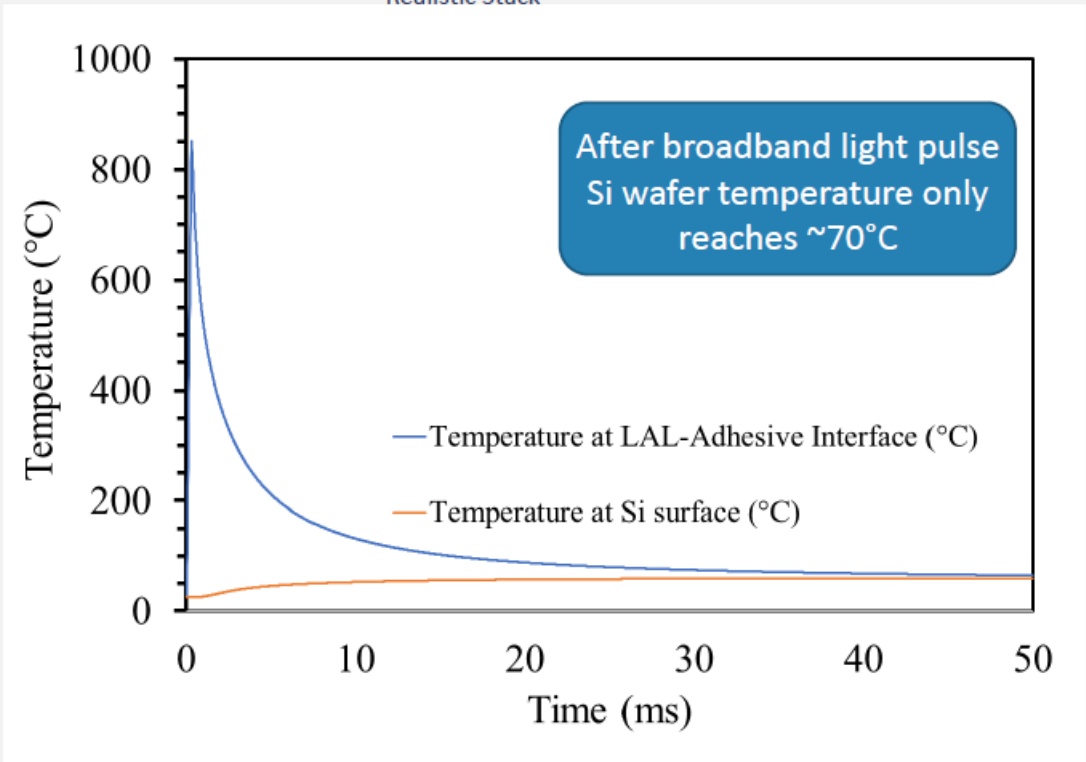
Thermal Simulation









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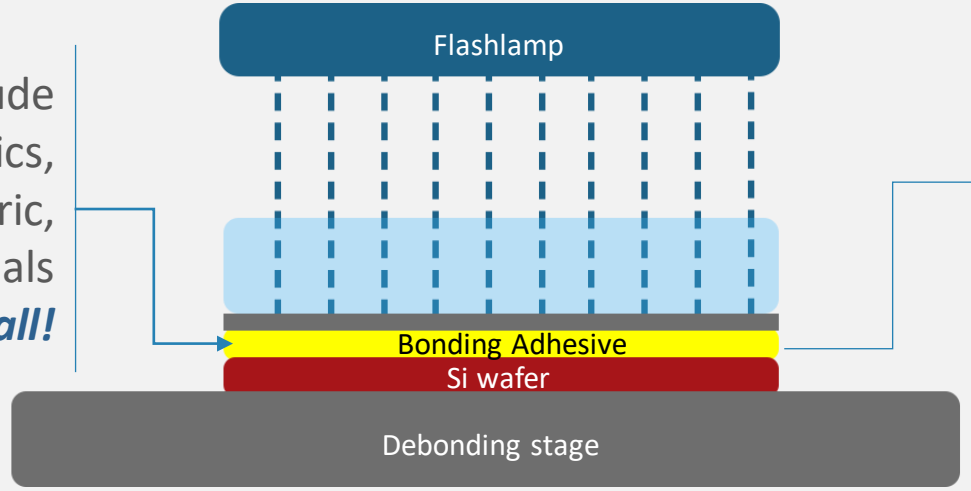
Extensive Qualification Through Collaboration

Adhesive may include thermoplastics, thermosetting, elastomeric, and combination materials

We can debond them all!



Open platform that works with a wide range of adhesives.

brewer science

RESONAC
Chemistry for Change

ShinEtsu

SEKISUI

HD MicroSystems™

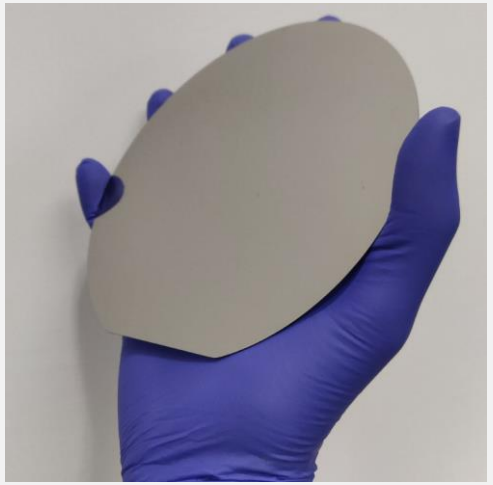
3M

KAYAKU ADVANCED MATERIALS

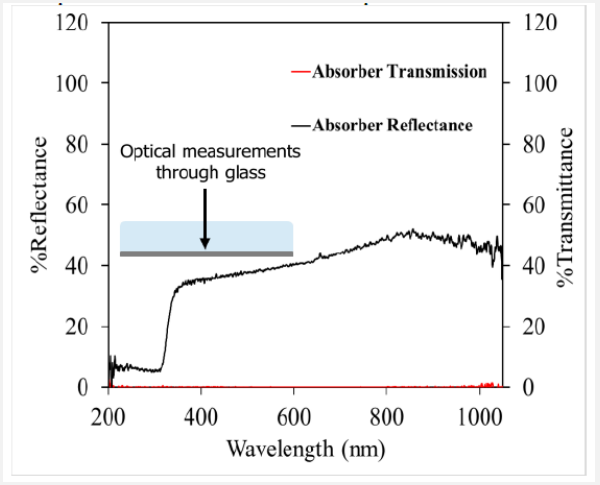
And others…

PulseForge®

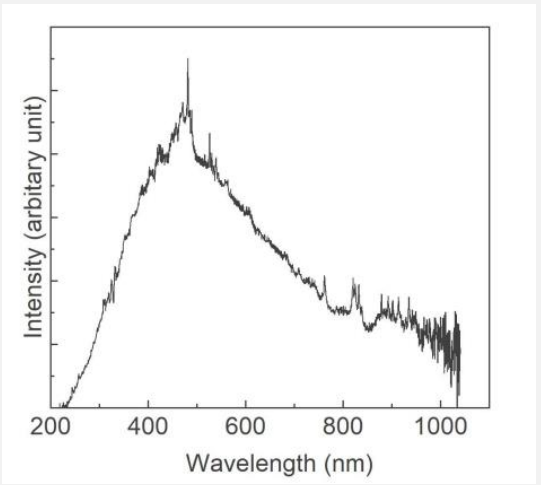
Light Absorber Layer (LAL) – Key to Successful Photonic Debond



Photograph of the LAL coated Carrier



Optical characteristics of the absorber layer



PulseForge Emission spectrum

- Light absorber is an **inorganic layer** on the glass carrier
- LAL is **crucial** for photonic debonding
- Two major functions
  - Block light transmission (~ 100%)
  - Convert the incident light energy to heat
- LAL coated carriers are **reusable up to 15 times**

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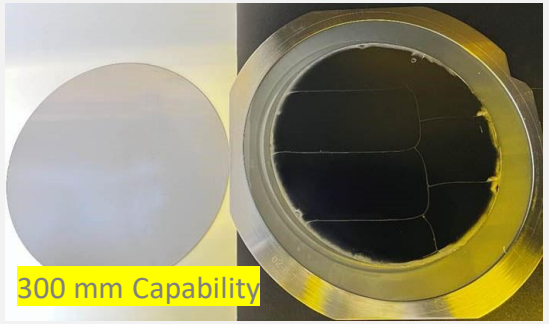
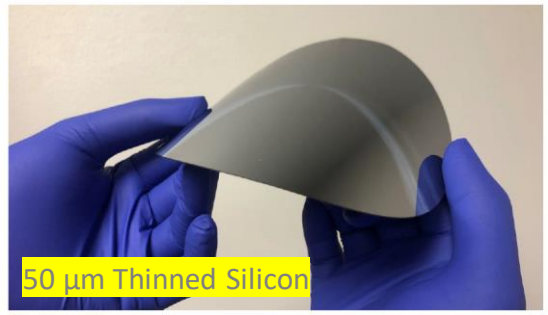
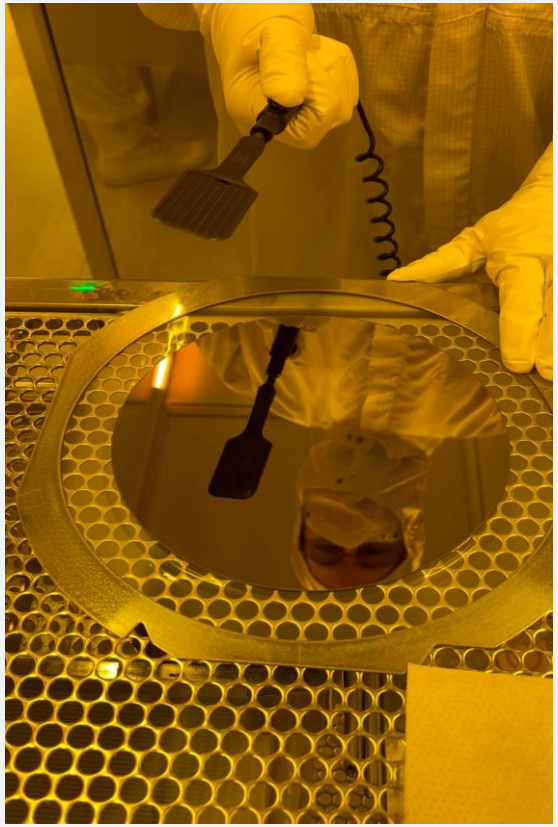
Photonic Debonding of Silicon Wafers

Using a wide range of adhesives



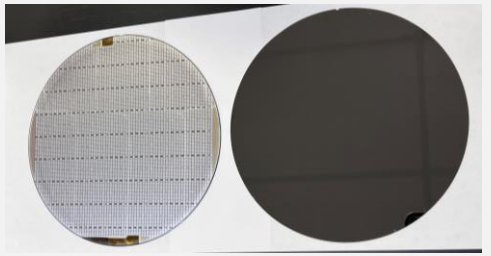




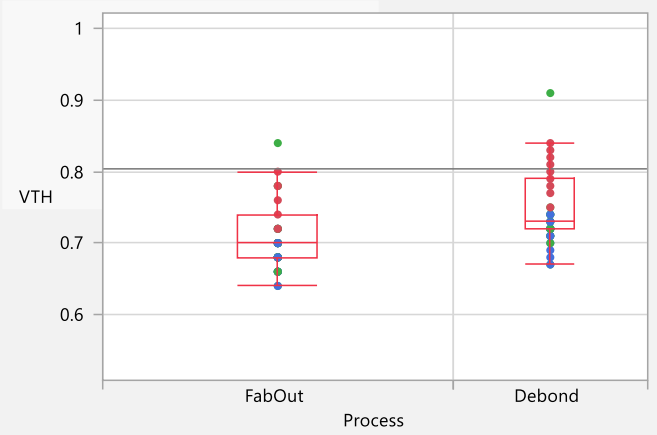
Evaluation with active devices from Applied Novel Devices

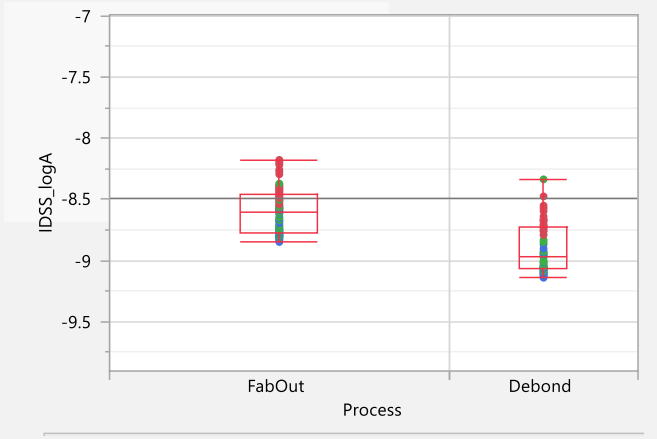
~ 100% device yield

- 200 mm wafer
- Power MOSFETs
- No residue



No impact on Vth and drain leakage current (25V) post photonic debond

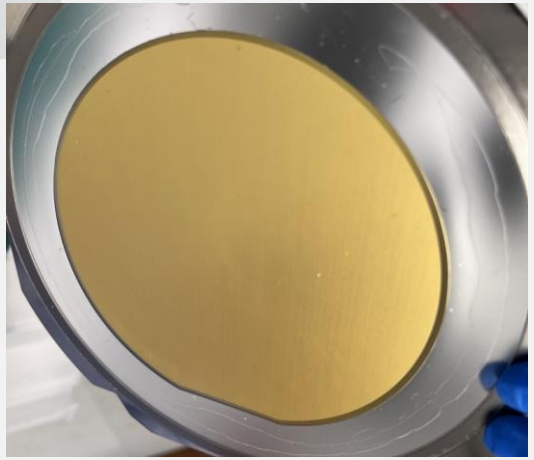


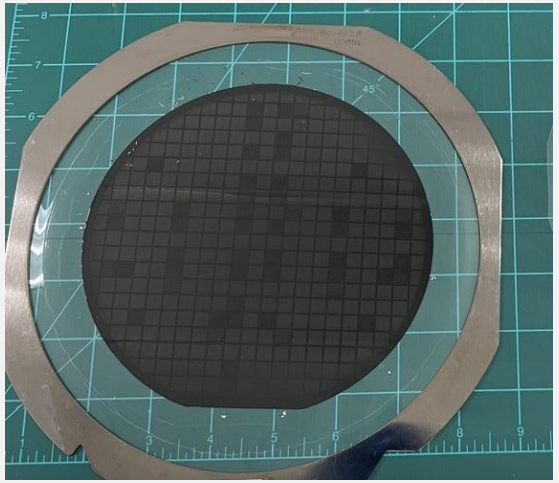


Photonic Debonding of Compound Semiconductors

Thinned (~100 µm) GaAs wafer
(150 mm) debonding

Thinned (~80 µm) SiC wafer
(150 mm) debonding





Other compound semiconductors work as well

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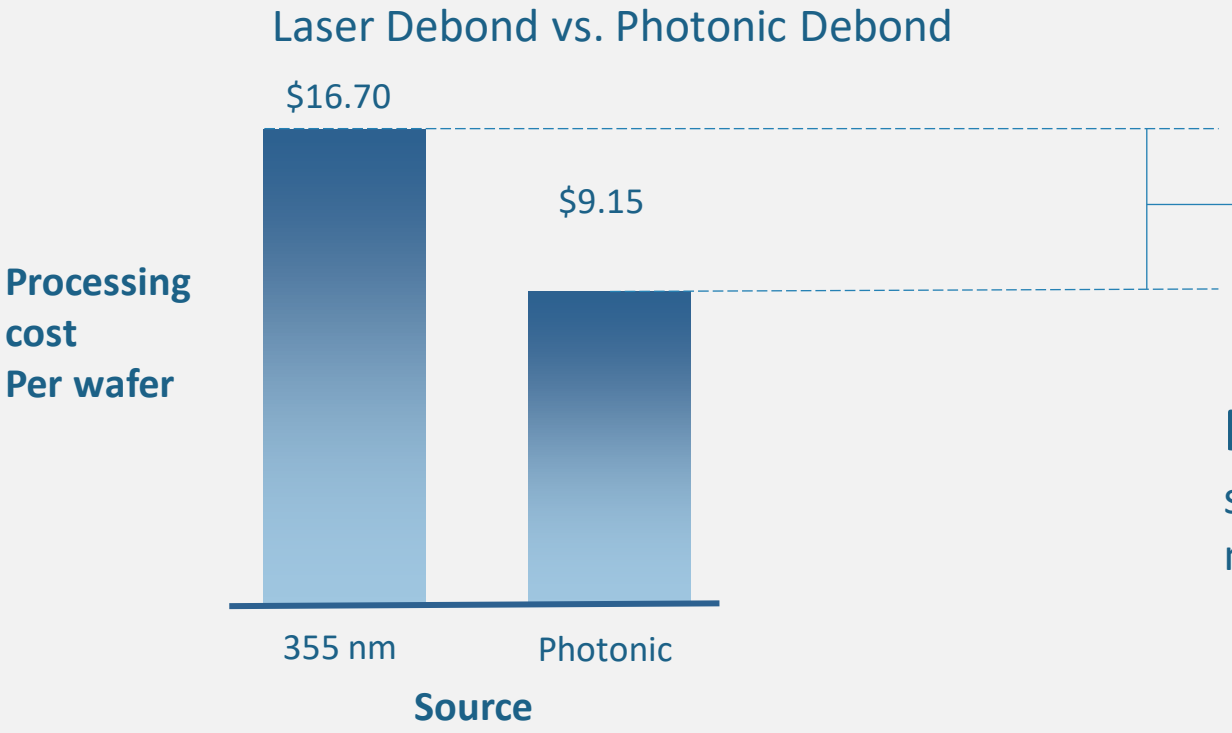
Photonic debonding
Cost advantage of Only the Debonding Step



Baseline savings of ≥ **40%** as compared to other methods!

Photonic Debonding

shows significant savings over laser debonding methods.

Assumptions:

- Glass carrier for 355 nm laser debonding ($50 for 300 mm)
- LAL coated carrier for photonic debonding ($120 for 300 mm)
- 40 wafers per hour throughput in both cases
- 7 ml of release layer for 300 mm wafers in laser debonding
- 15 times carrier reusability with Photonic and 5 times carrier reusability with laser

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Key Technical Advantages of Photonic Debonding

No Transmission of Light

Light absorber layer (LAL) prevents transmission of the light to the absorber layer, resulting in no exposure on the device wafer.

Why it matters: No exposure of the devices eliminates the negative impact of light. Leads to higher yields.

Low Thermal Impact on Devices

Once the LAL layer and adhesive are separated, there is minimal thermal conduction between the two layers.

Why it matters: Photonic debonding is a self-limiting process. Enabling separation with < 70C thermal load on the devices, limiting temperature rise in the device layer as compared with incumbent processes.

Low Stress

Vaporization of the adhesive creates an air gap results in nearly stress-free separation of the carrier and devices.

Wide area illumination, combined with multi-angled illumination, results in high tolerance for imperfections, like dust particles.

Why it matters: Photonic debond is applicable to a wider range of devices as there is minimal stress on the device layer during separation.

Clean Process

The adhesive film is only exposed to heat from the LAL near the interface. No illumination of the adhesive that could lead to carbonization.

Easier and gentler cleaning process post debond.

Why it matters: Prevents material contamination from the adhesive residue that hampers the device yield in incumbent processes. Suitable for hybrid bonding (3D ICs).

High Yield Process

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Key Technical Advantages of Photonic Debonding

High Temperature Processing

LAL carriers support high temperature device fabrication. Adhesives that work up to 450C have been qualified.

Why it matters: Facilitates higher temperature back side processing for enhanced device performance. New materials and devices are achievable.

Enhanced Device Performance

Key Economical Advantages of Photonic Debonding

Higher Throughput

Wide area illumination and high repetition rate of pulsing accelerates the debonding process. The exposure on a full 300 mm wafer is done in 15 seconds.

Why it matters: Removes debonding as limiting factor for the process.

Reusability of Carriers

Flash lamp exposure does not change the performance of the carrier. Resulting in reusability of the carriers. Leading to significant reduction in cost of ownership.

Why it matters: Opens a wider range of devices by making them economically feasible.

Simplified Optics

PulseForge system is built with a very durable optics system with no movable parts. Lamps are the primary consumable, changeable in < 5 min.

Why it matters: Reduced complexity and cost of PM cycles.

Compatibility with warped devices and 3D architecture

PulseForge has a working distance between 5 to 15 mm. No need for a warpage correction tool on the system.

Why it matters: PulseForge can accommodate a wide range of warped wafers without additional hardware.

Clean Process

No direct illumination of the adhesive leads to no carbonization, requiring less expensive cleaning equipment. Less cleaning materials is needed.

Why it matters: Significant reduction in cleaning costs.

Simplified Bonding Step

Coating of the adhesive required only on the device wafer. Simplifying the bonding step and lowering the bonder costs.

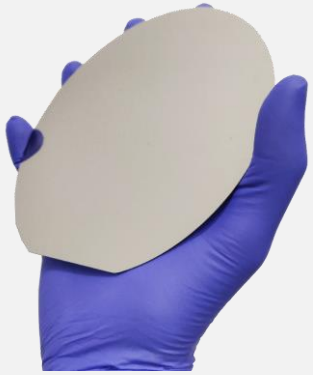
Why it matters: Eliminates the cost associated with the additional coater, baker and laser release layer.

PulseForge®

PulseForge Solutions

Photonic Debonding – Complete Solution

Carriers



Reusable light absorbing layer coated carrier

Tools

Fully automated photonic debond tool solutions

PulseForge PD-300SA
Semiautomated photonic debond tool

PulseForge Embed
photonic debond module

These light absorber layer coated glass carriers are integral part of photonic debond solution offering key benefits in significantly lowering the cost per wafer.

PulseForge®

PulseForge Integration Partners

Teikoku Taping Systems
Aichi, Japan

ERS electronic GmbH
Munich, Germany

NADATech,
Austin, Texas

Scientech Corp
Hsinchu, Taiwan

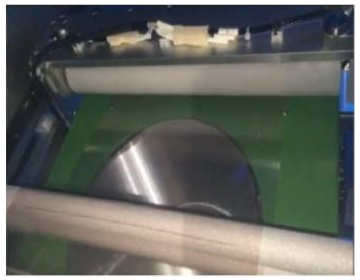
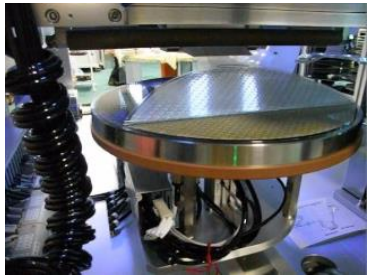
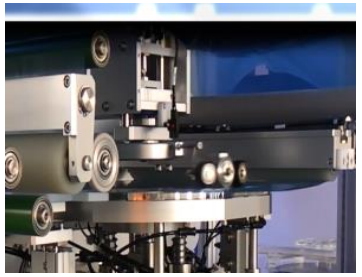
Company Profile

President	:	Ichiro Tomonaga
Date of establishment	:	1995/12/14
Address	:	43-1, Harabuto, Kagiya-Machi, Tokai-City, Aichi, JAPAN
TTS Subsidiary	:	Teikoku Taping System, Inc (Phoenix, AZ, USA)
	:	Teikoku Taping System(Singapore) Pte Ltd (SINGAPORE)
Shareholder	:	Nippon Kayaku Co., Ltd. - 100%
Industry	:	Semiconductor manufacturing equipment manufacturing

TTS Product Portfolio

TEIKOKU TAPING SYSTEM Equipment Group

- Tape laminator, tape remover, wafer mounter, UV irradiator
- Equipment for wafers and panels is available for the above process equipment.

	Wafer Level				Panel Level	Wafer Level
						
TTS Product	DXL2 / EXL2	DXR2 / EXR2	CXM / EXM	FMUV	CPL / CMD	VXL / PDT
Process Segment	BG Tape Laminator DFR Laminator DAF Laminator Vacuum Laminator Custom Lamination	BG Tape Remover Cover Film Remove Custom Tape Remover	Dicing Tape Mounter w/ BG Tape Remover De-Mount / Reverse Wafer Mounter Custom Mounting	UV Irradiation for UV Dicing Tape & Temporary Bonding Tape	Tape Laminator Tape Remover Panel Mounting Panel De-Bonding	Temporary Bonding Temporary Debonding (UNDER DEVELOPMENT)
Tool Segment	Tape Laminator	Tape Remover	Wafer Mounter	UV Irradiation	Tool for Panel	Bonding/Debonding

Key Benefits of Photonic Debonding

- Lower processing costs by more than 40%
- Cleaner process – no ash or residue
- Compatible with warped substrates
- Qualified by multiple adhesive suppliers
- Faster throughput: > 60 WPH
- Inorganic LAL supports high temperature device fabrication (up to 450 °C)
- High yield
- No impact of light on the device structure

Thank you!

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