PermiNex® 2000

Low Temperature, Photoimageable Bonding Adhesive

Description

Kayaku Advanced Materials' PermiNex® 2000 is an epoxy based, photoimageable bonding resist used as an adhesive layer for the definition and capping of cavity structures such as BAW, SAW, microfluidic devices, and others, where critical alignment, low temperature processing and high bond quality are desired. PermiNex® 2000 is available in four standard viscosities allowing film thicknesses of 1 to > 25 µm to be achieved in a single coat and is developed in a conventional alkaline developer (TMAH).

Features

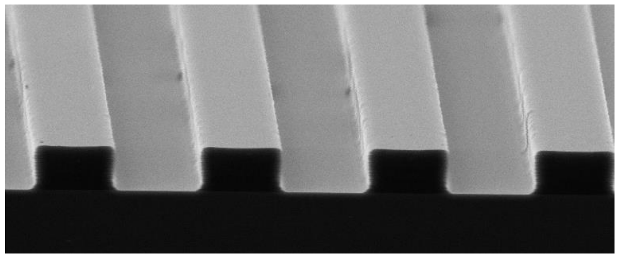
- Permanent wafer bonding adhesives for non-hermetic applications
- Negative-tone, photoimageable adhesives
- Aqueous developer compatible
- i-Line exposure
- Low temperature processing at < 200°C
- High quality, void free bonding
- Superb adhesion to silicon and glass

Processing Guidelines

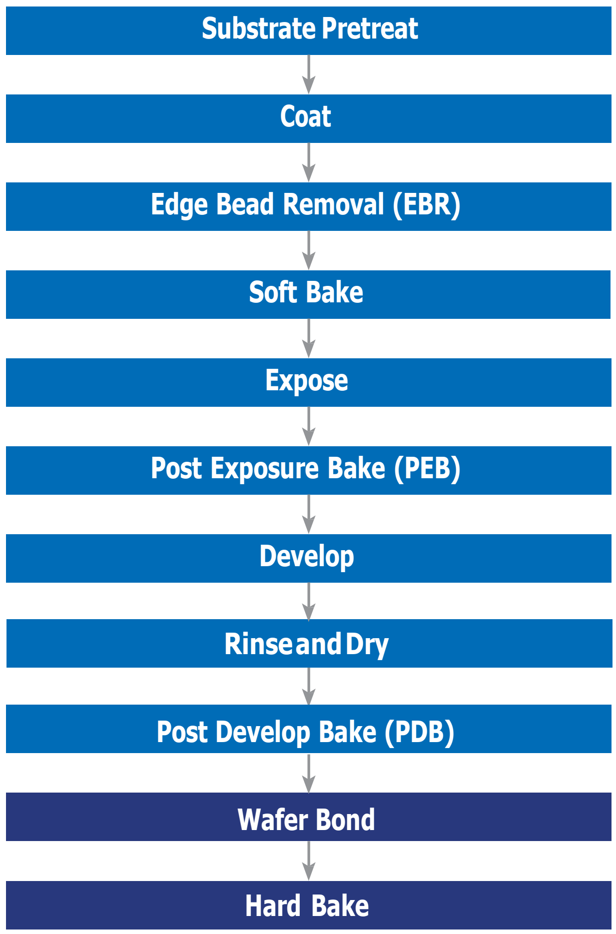
The following conditions represent Kayaku Advanced Materials' recommendation for a baseline process. It is expected that a certain amount of engineering and optimization will be required for customer-specific systems, facilities and application. For

application, please contact your local Kayaku Advanced Materials' Technical Sales Representative

bonding process flow is depicted in Figure 1.



5 µm thick PermiNex® 2000 coating



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Photolithography

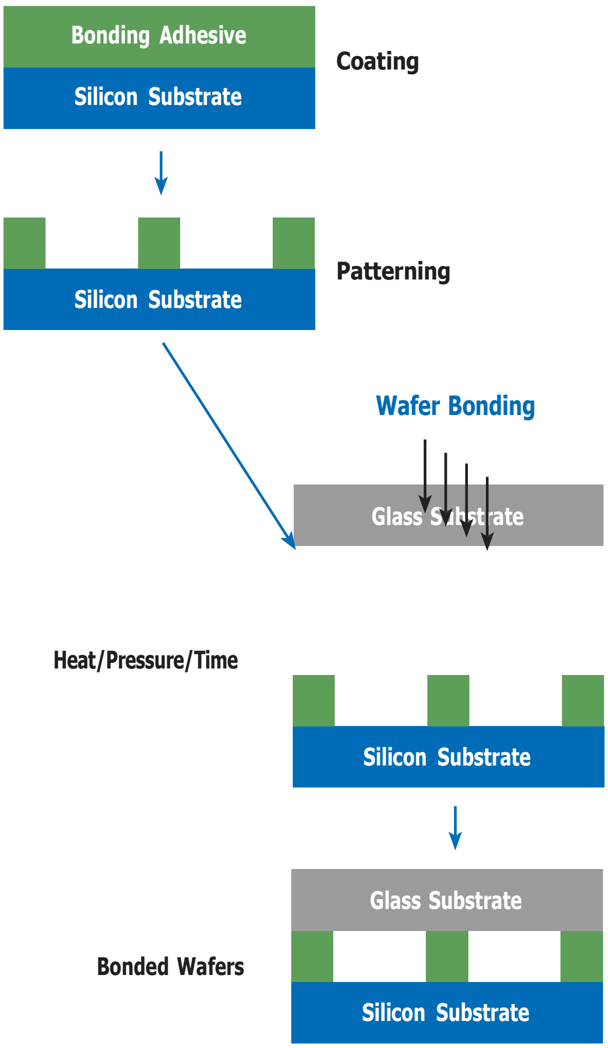

Figure 1. General Bonding Process Flow

Substrate Preparation

To obtain maximum process reliability, substrates should be clean and dry prior to applying PermiNex® 2000 resist. For best results, substrates should be cleaned with a piranha wet etch (using H_2SO_4 & H_2O_2) followed by a de-ionized water rinse. Substrates may also be cleaned using reactive ion etching (RIE) or any barrel asher supplied with oxygen.

Coat

PermiNex® 2000 bonding resists are available in four standard viscosities, as shown in Table 1. The film thickness vs. spin speed curves are displayed in Figure 2. The curves were generated using a Brewer Science®, Model # Cee® 200 coater, static dispense on 6" (150 mm) silicon wafers and a soft bake of 95°C (times listed below in Table 2) on a level hot plate. The curves provide a guideline for selecting the appropriate PermiNex® 2000 resist and spin conditions to achieve the desired film thickness. Please note that the exact thickness obtained may be slightly offset from Figure 2 due to equipment type, setting differences and room conditions.

PermiNex® 2000	Viscosity (cSt)	Density (g/mL)
2001	7	1.00
2005	70	1.06
2010	400	1.10
2015	1200	1.12

Table 1. PermiNex® 2000 Viscosity

Recommended Program

(1) Dispense 1 ml of resist for each inch (25 mm) of substrate diameter.

(2) Spin at 500 rpm for 5-10 seconds with acceleration of 500 rpm/second.

(3) Spin at 3000 rpm for 30 seconds with acceleration of 500 rpm/second.

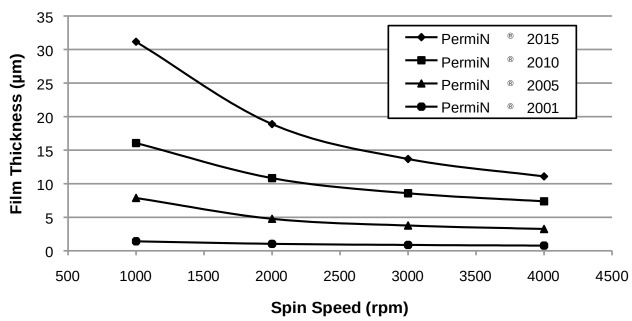

Figure 2. PermiNex 2000® Thickness vs. Spin Speed

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Edge Bead Removal

For thicker films ≥ 5 µm, an edge bead removal step may be necessary during the spin-coating process, as a buildup of photoresists is likely to occur on the outer edge of the substrate. The edge bead prevents close contact of the photomask with the wafers resulting in poor aspect ratio and resolution, and subsequently poor bonding quality due to non-uniform film thickness. In order to achieve the best lithographic and bonding results, the thick bead should be removed. This can be accomplished by using a small stream of Kayaku Advanced Materials' EBR PG at the edge of the wafer either at the top or from the bottom. For edge bead removal using EBR PG, please refer to the EBR PG technical data sheet.

Soft Bake

A level hotplate with good thermal control and uniformity is recommended for use during the Soft Bake step of the process. Convection ovens are not recommended. During convection oven baking, a skin may form on the resist. This skin can inhibit the evolution of solvent, resulting in incomplete drying of the film and/or extended bake times. Table 2 shows the recommended Soft Bake temperatures and times for the various PermiNex® 2000 products at selected film thicknesses.

THICKNESS microns	SOFT BAKE TIMES Minutes @ 95°C
1	5 - 8
5	5 - 10
10	10 - 12
15	15 - 15

Table 2. Soft Bake Times

Optical Parameters

The dispersion curve and Cauchy coefficients are shown in Figure 3. This information is useful for film thickness measurements based on ellipsometry and other optical measurements.

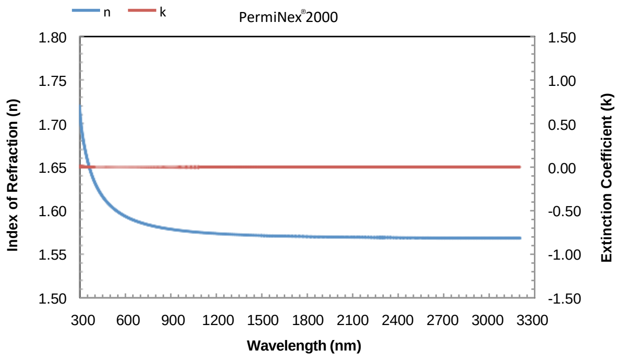

Figure 3. Cauchy Coefficients

Exposure

Table 3 gives the recommended baseline exposure dose to produce 10 µm lines and spaces on silicon at various resist thicknesses obtained in contact mode using an EVG 620 with a HAS 500 Mercury Short Arc Lamp (Advanced Radiations Corporation) and PL-360LP long pass filter (Omega Optical). The use of a long pass filter, such as the PL-360LP from Omega Optical, is recommended when using a mask aligner to eliminate UV radiations below 350 nm and obtain vertical sidewalls in the PermiNex® 2000 resists.

Note: With optimal exposure, a visible latent image will be seen in the film within 5–15 seconds after being placed on the PEB hot-plate and not before. An exposure matrix should be performed to determine optimum dosage.

THICKNESS microns	EXPOSURE ENERGY mJ/cm^2
1	700–900
5	800–1000
10	1000–1200
15	1100–1300

Table 3. Exposure Dose

Post Exposure Bake (PEB)

A post exposure bake is required to complete the curing reaction and should take place directly after

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exposure. Table 4 shows the recommended time and temperature for various approximate thickness targets.

THICKNESS microns	**PEB TIME** minutes @ 70˚C
1-15	2

Table 4. PEB Time

Development

PermiNex® 2000 series resists have been designed for development in 2.38% TMAH (0.26 N) aqueous alkaline developer in immersion, spray, puddle or spray/puddle processes. Strong agitation is recommended when developing high aspect ratio and/or thicker structures. The recommended development times for an immersion process are given in Table 5.

THICKNESS microns	**DEVELOPMENT TIME** minutes
1	1
5	1
10	1.5
15	2

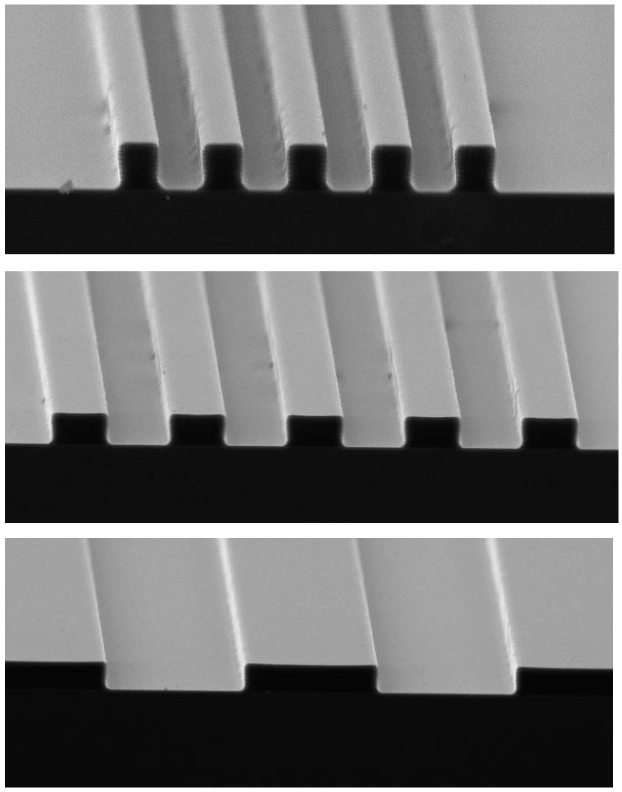
Table 5. Development Times for 2.38% TMAH

Rinse and Dry

Following TMAH development, spray rinse the developed image with fresh 2.38% TMAH for the approximate times listed in Table 6 below, followed by spray rinse with deionized water for 20 seconds and then dry with filtered, pressurized air or nitrogen.

THICKNESS microns	**RINSE TIME** seconds
1	15
5	20
10	25
15	30

Table 6. Rinse Times with 2.38% TMAH



5, 10, 25 µm features, 5 µm thick PermiNex® 2000 coating
Contact Aligner Exposure

Post-Develop Bake (PDB)

A post-develop bake at 180˚C for 5 minutes should be conducted prior to bonding, to eliminate any residual developer trapped in the film that could impact the subsequent bond quality. A ramped cool down step may be necessary to mitigate stress in thicker films.

Bonding

The bonding process steps are listed below and bonding parameters summarized in Table 7. The bonding parameters are specific to a 6" (150 mm), 575 µm thick patterned Si wafer bonded to a glass wafer using an Ayumi AD-300 wafer bonder. Bonding parameters should be optimized for different bonding tools, wafer type, size and thickness, surface topography, bond pattern and coverage area.

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Bonding steps:

1. Set stage temperature to 150˚C
2. Assemble wafers for bonding
3. Establish vacuum at 9-10 Pa
4. Bonding: ramp pressure and hold at 10.6 kN (0.58 MPa) for 30 seconds
5. Optional Hard-Bake at 180˚C for 60 minutes (see below)
6. Release vacuum
7. Remove bonded wafers

WAFER SIZE	RESIST THICKNESS	TEMPERATURE		FORCE
inches	microns	˚C	seconds	kN
6	1–15	150	30	10.6

Table 7. Bonding Parameters

The silicon to glass bonding performance of 10 µm thick patterned PermiNex® films was also evaluated in a SUSS MicroTec SB8e bonder (pillar structure) and EV Group EVG529IS bonder (pixel structure). High strength and high quality bonding was obtained at 150˚C/30 seconds at forces in the 10-16 kN range.

Hard Bake

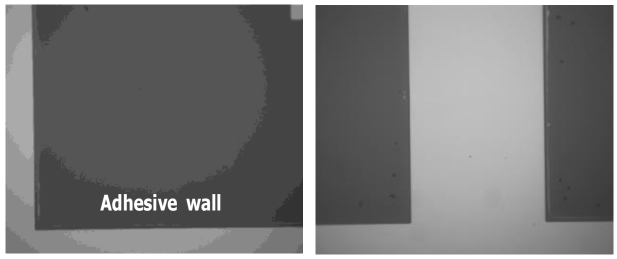
For maximum bond strength and integrity, a 180˚C/60 minutes hard bake should be incorporated after the bonding step.

Bond Characterization

A glass wafer was bonded to a patterned silicon wafer to facilitate visual inspection of the bonding interface through the glass wafer. No critical voids or defects were observed.

Representative visual inspection images were obtained after bonding 10 µm films (pixel pattern) in the EV Group EVG529IS bonder.

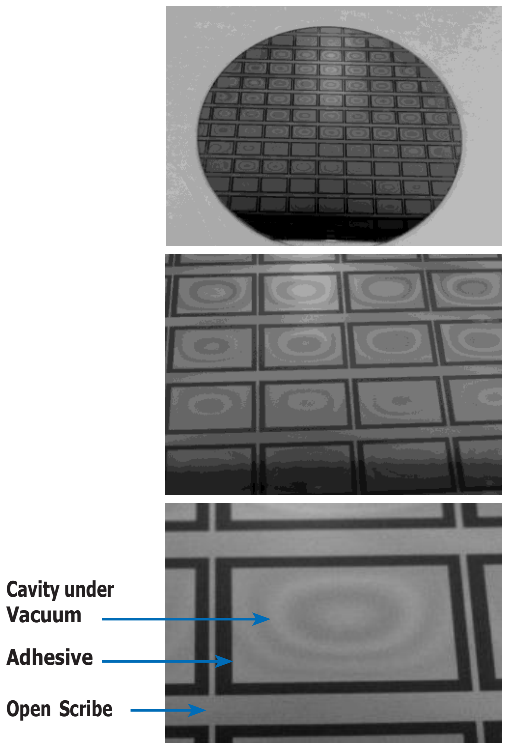
Visual Inspection



10 µm thick polymer adhesive cavity wall
No visible cracking at high aspect corner structures
and void-free conformal interface

Seal Quality

The bonded wafers are submerged in water. Water flows into the open scribe channels. Voids or defects in the bond layer will create pathways for water to enter the cavity. Vacuum is applied, visual inspection reveals Newton rings, which indicates void free, successful bonds.



Bonded glass to silicon test cavity structure
10 µm thick polymer adhesive
Demonstrated high seal integrity

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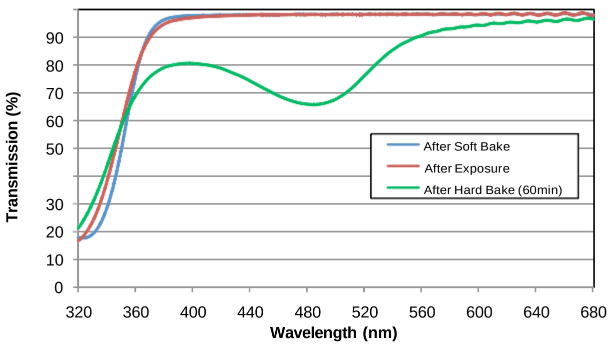
Optical Properties



Process conditions (10 µm film):
Softbake: 10 minutes at 95˚C
Exposure: 800 mJ/cm^2
Hardbake: 60 minutes at 180˚C

Figure 4. Optical Transmission

Physical Properties
(Typical values)

Shear Adhesion on Si (MPa)	55
Shrinkage (%)	5
Tg (˚C)	105
Thermal Stability in Air, 5% wt. loss (˚C)	296
CTE (ppm/˚C)	98
Young's Modulus (GPa)	2.3
Elongation (%)	5
Residual Stress (MPa)	9
Tensile Strength (MPa)	68
Electric Strength (V/µm)	115
Resistivity (Ω.cm)	10^{14}

Storage

Store PermiNex® 2000 resists frozen in tightly closed, upright containers at 14˚F (-10˚C). Store away from light, acids, heat and sources of ignition. Shelf life is thirteen months from date of manufacture for storage at 14˚F (-10˚C) and typically two to three months at room temperature prior to use. Defrost PermiNex® 2000 at room temperature for 24 hours prior to use.

Handling

Consult Safety Data Sheet (SDS) for details on the handling procedures and product hazards prior to use. If you have any questions regarding handling precautions or product hazards, please email *productsafety@kayakuAM.com.*

Disposal

The material and its container must be disposed in accordance with all local, state, federal and/or international regulations.

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