PermiNex™ 1000

Low Temperature, Photoimageable Bonding Adhesive

DESCRIPTION

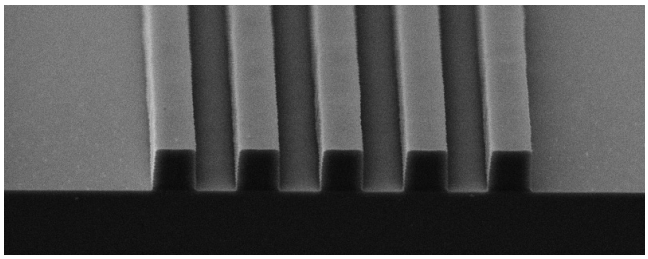
MicroChem PermiNex 1000 is an epoxy based, photoimageable bonding resist used as an adhesive layer for the definition and capping of cavity structures such as BAW, SAW, microfluidic devices, and others, where critical alignment, low temperature processing and high bond quality are desired. PermiNex 1000 is available in four standard viscosities allowing film thicknesses of 1 to > 25 µm to be achieved in a single coat.

FEATURES

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

PROCESSING GUIDELINES

The following conditions represent MicroChem's 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 guidance on optimizing the process for a specific application, please contact your local MicroChem Technical Sales Representative or MicroChem Technical Support. The overall PermiNex 1000 bonding process flow is depicted in Figure 1.



5 µm thick PermiNex 1000 coating

PermiNex™ 1000

PHOTOLITHOGRAPHY

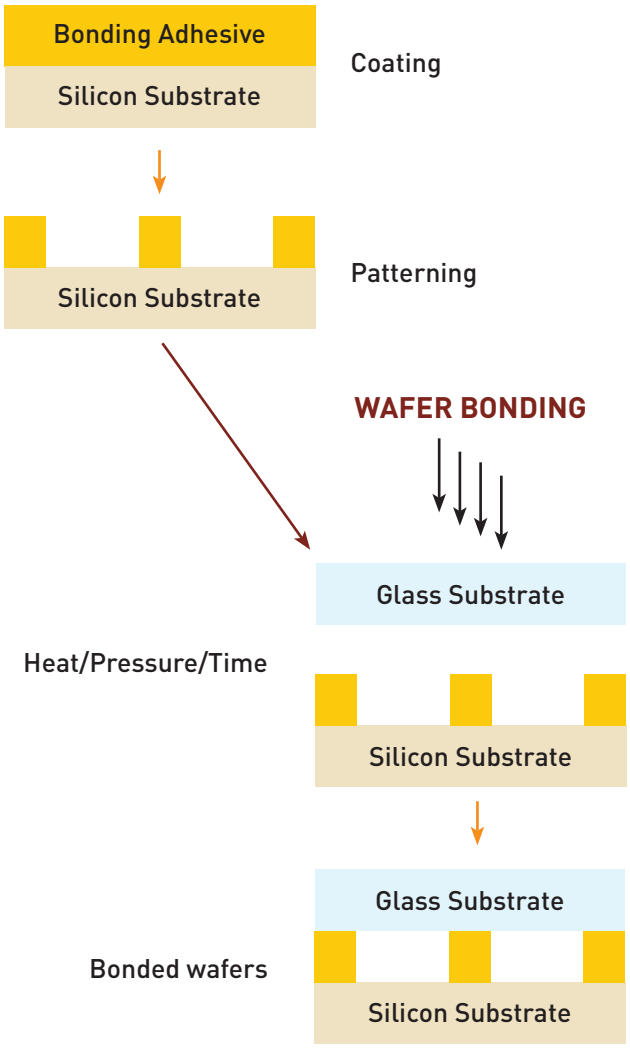


Figure 1. General bonding process flow

Substrate Preparation

To obtain maximum process reliability, substrates should be clean and dry prior to applying PermiNex 1000 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 1000 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 a 6" (150 mm) silicon wafers and a soft bake of 95°C (times listed below in Table 2) on a level hot plate and provide a guideline for selecting the appropriate PermiNex 1000 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 1000	Viscosity (cSt)	Density (g/mL)
1001	10	0.99
1005	135	1.06
1010	700	1.09
1015	1200	1.10

Table 1. PermiNex 1000 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.

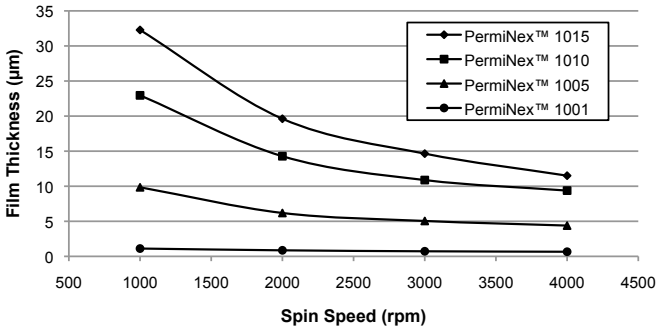


Figure 2. PermiNex 1000 Thickness vs. Spin Speed

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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 build-up 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, this thick bead should be removed. This can be accomplished by using a small stream of MicroChem's 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 1000 products at selected film thicknesses.

THICKNESS microns	SOFT BAKE TIMES Minutes @ 95˚C
1	2 - 4
5	4 - 8
10	10 - 15
15	15 - 25

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.

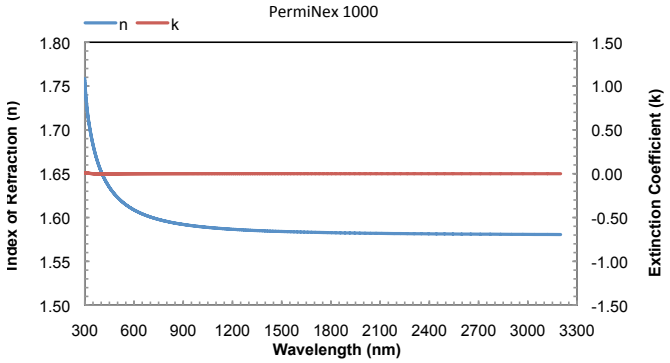


Figure 3. Chauchy Coefficients

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 1000 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	360 - 800
5	480 - 800
10	640 - 800
15	720 - 800

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

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

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

Table 4. PEB Times

Development

PermiNex 1000 series resists have been optimized for development in PN 1000 Developer (solvent blend). They can be developed in a variety of develop modes including immersion, spray, puddle or spray/puddle. Strong agitation is recommended when developing high aspect ratio structures and/or thicker structures. The recommended development times for an immersion process are given in Table 5.

THICKNESS microns	DEVELOPMENT TIME minutes
1	4
5	4
10	7
15	10

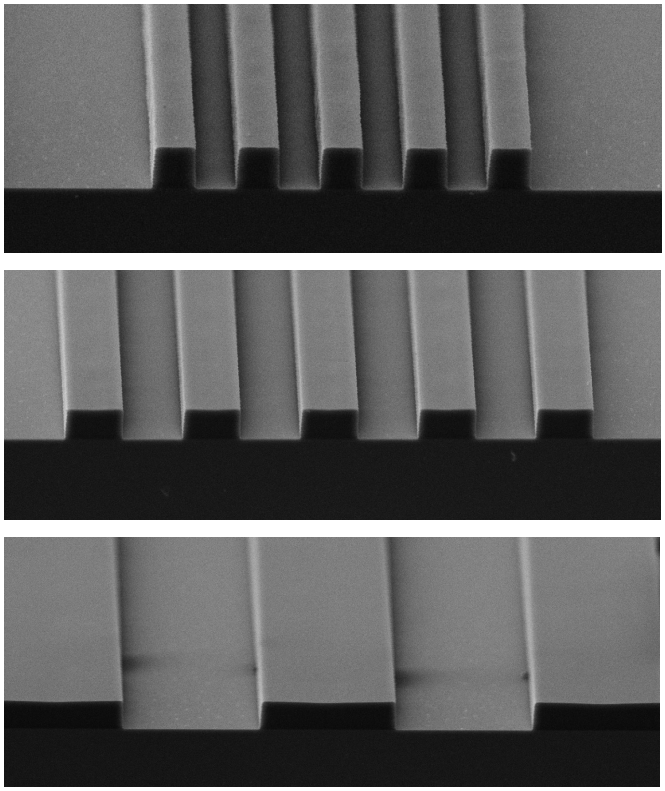
Table 5. Development Times for PN 1000 Developer

Rinse and Dry

When using PN 1000 Developer, spray rinse the developed image with fresh developer for the approximate times listed in Table 6. Dry with filtered, pressurized air or nitrogen.

THICKNESS microns	RINSE TIME seconds
1	10-15
5	10-15
10	10-15
15	25-30

Table 6. Rinse Times with PN 1000 Developer



5, 10, 25 µm features, 5 µm thick PermiNex 1000 coating Contact Aligner Exposure

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.

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 page 5)
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, an 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.

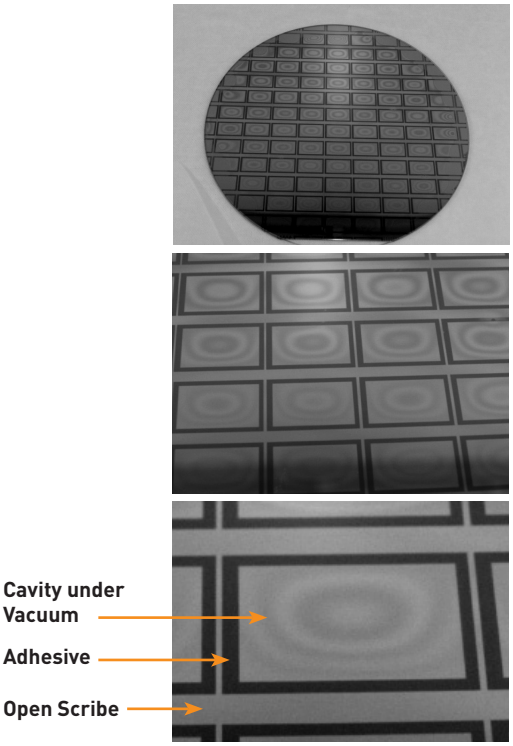
Representative images below were obtained after bonding 10 µm films (pixel pattern) in the EV Group EVG529IS bonder.

Visual Inspection

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

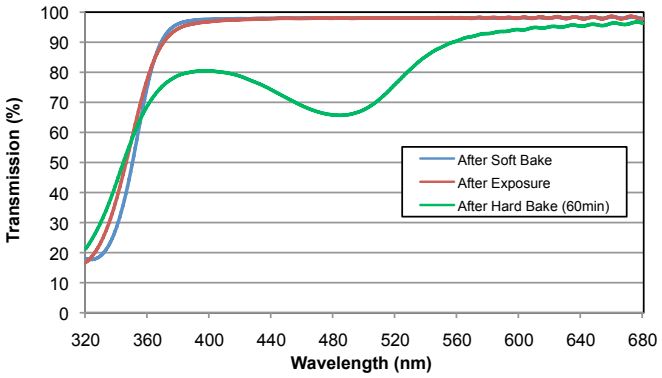
Seal Quality

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

OPTICAL PROPERTIES



Process conditions (10 µm film):
Softbake: 12 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)	90
Young's Modulus (GPa)	2.2
Elongation (%)	5
Residual Stress (MPa)	10
Tensile Strength (MPa)	65
Electric Strength (V/µm)	115
Resistivity (Ω.cm)	10^{14}
Water Absorption (%)	0.6

STORAGE

Store PermiNex 1000 resists upright and in tightly closed containers in a cool, dry environment, away from direct sunlight at a temperature of 40-70˚F (4-21˚C). Store away from light, acids, heat and sources of ignition. Shelf life is thirteen months from date of manufacture.

DISPOSAL

PermiNex 1000 resists may be included with other waste containing similar organic solvents to be discarded for destruction or reclaim in accordance with local state and federal regulations. It is the responsibility of the customer to ensure the disposal of PermiNex 1000 resists and residues is made in observance of all federal, state, and local environmental regulations.

ENVIRONMENTAL, HEALTH AND SAFETY

Consult with the product SDS before working with PermiNex 1000 resists. Handle with care. Wear chemical goggles, chemical gloves and suitable protective clothing when handling PermiNex 1000 resists. Do not get into eyes, or onto skin or clothing. Use with adequate ventilation to avoid breathing vapors or mist. In case of contact with skin, wash affected area with soap and water. In case of contact with eyes, rinse immediately with water and flush for 15 minutes lifting eyelids frequently. Get emergency medical assistance.

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