



Revised September 2008

PRODUCT BULLETIN

PI-2562 Polyimide

PI-2562 polyimide is supplied as a high solid content solution suitable for spin coating applications. This characteristic makes it ideally suited for gap filling and planarization applications. A separate adhesion promoter is recommended to provide optimum adhesion. Processing by plasma etch is recommended.

Processing Details Apply Adhesion Promoter

An aminosilane based adhesion promoter such as VM-651 or VM-652 should be used to enhance adhesion to silicon, ceramic or patterned metallization. Prior to application the substrate should be free of particles and any surface contamination. The maximum recommended hold-time between application of adhesion promoter and polyimide apply is 48 hours.

Apply Polyimide

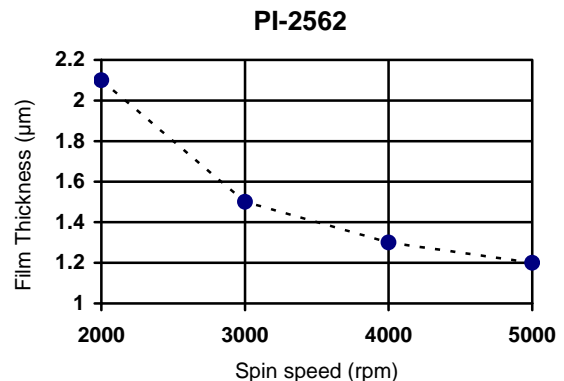
PI-2562 polyimide solution is highly viscous due to the high molecular weight. Application can be accomplished by manual dispense such as an automatic syringe for prototyping or by a dispensing pump or comparable system on automated lines capable of handling high viscosity, NMP based, polyimides. Never open a refrigerated bottle of polyimide until it has had time to fully warm up to ambient temperature.

Both static and dynamic dispensing techniques may be used depending on substrate size and available tooling. Typically static dispense is the easiest to integrate but requires more material per substrate. Dynamic dispense uses less material, but requires greater control during operation. In either case it is important to assure that the polyimide is dispensed in the exact center of the wafer. Acceleration to final spin speed should be as slow as possible to allow the polyimide to flow across the substrate. Often one or more intermediate spin speeds can be used to allow the polyimide to gradually cover more than 80% of the substrate before continuing on to the final spin speed.

The final spin speed and spin time is determined by the film thickness required (see chart below). To reduce backside contamination potential it is often beneficial to prolong the spin cycle until the bulk of the excess polyimide has been removed from the substrate. Longer spin times will improve coating uniformity but will reduce the film thickness. In production applications an edge bead remover (EBR) and/or backside rinse (BSR) maybe added to the coating cycle to remove polyimide from the edge and back of the wafer prior to baking. Commercially available NMP or cyclopentanone based solvent blends can be used for this purpose.

Spin Speed Curves

(Coated for 30 seconds at indicated speed, cured 30 minutes at 350°C)



Soft Bake

A soft-bake is typically done after coating on in-line hot plate(s) on the coater track. Soft-bake temperatures range from 90 – 150°C for 90 – 300 seconds in the full contact or proximity mode. Detached hot plates or convection ovens can also be use for the soft-bake. After spinning and during soft-bake the wafers should be kept in a horizontal position. Only ventilated ovens should be used for polyimide curing. Soft-bake times in convection ovens are typically 30 – 40 minutes.

Curing

As with standard polyimides, the PI-2562 curing process converts the polyamic acid into a fully aromatic, insoluble polyimide and drives off the NMP solvent carrier. This process requires elevated temperatures and controlled environments to achieve the best results. There is sufficient energy at 200°C to nearly complete the polyimide imidization process. However, higher temperatures are required to completely dissociate the carrier solvent, fully imidize the film and complete polymer orientation, thereby optimizing electrical and mechanical properties.

Final curing can be done in a programmable oven or diffusion tube furnace. To activate the adhesion promoter, it is recommended that the cure be carried out up to 200°C in air (min 50% RH). Above this temperature a nitrogen atmosphere should be used. The ramp rates (up and down) should be low to avoid high stress in the polyimide. The loading temperature can be at ambient or at the previous soft-bake temperature.

Final cure temperatures are predicated around the desired ultimate cured film properties and subsequent processing temperatures. The maximum cure temperature may be higher than 350°C when the coating is to be subjected to high temperature process after curing. In such cases, temperatures up to 400°C have been used to ensure that there is no outgassing during subsequent processes.

Etch Mask

It is usually considered preferable to select an etch mask which has a lower etch rate in the etch gas mixture chosen compared to the polyimide. Patterned hard masks such as aluminum have very low etch rates in O₂/CF₄ mixtures. Other masks such as spin-on-glass may have faster etch rates.

Both dry etch processing and laser ablation techniques have become the preferred process routes for patterning PI-2600 Series polyimides. These films are difficult to pattern using traditional wet etch techniques due to the molecular structure and inherent film density.

For dry etch processing, a non-erodible dry etch mask is deposited over the cured film. This etch mask should have an inherently lower etch rate than the polyimide in an oxygen based, dry etch gas mixture. Patterned aluminum and CVD have been successfully used as dry etch masks.

Example of Typical Process Conditions

Application of Adhesion Promoter (VM-652 or diluted VM-651)

- Dispense on static substrate, 3 seconds
- Hold for 20 seconds
- Spin Dry for 30 Seconds

Apply Polyimide Coating

- Dispense on static substrate
- Spread at 500rpm for 5 seconds
- Spin at final speed for 30 seconds
- EBR / Backside rinse, 10 seconds
- Spin Dry, 15 seconds
- Hot plate bake at 120°C for 300 seconds

Cure Polyimide

- Heat from RT to 200°C, ramp rate 4°C/min
- Hold at 200°C for 30 minutes in air
- Heat from 200°C to 350°C, ramp rate 2.5°C/min in nitrogen
- Hold at 350°C for 60 minutes in nitrogen
- Gradual cooling to RT

Pattern Polyimide

Dry Etch Process

- Dehydration bake: 100-200°C, 30 minutes
- Deposit dry etch mask, e.g. aluminum
- Apply photoresist over etch mask
- Image desired pattern
- Load wafers in dry etch tool
- Set parameters to pattern polyimide
Typical: 30mTorr for RIE
100 – 200mTorr for plasma etching
- Reset parameters to pattern polyimide
- Reset parameters to strip dry etch mask
- If necessary, clean vias using back sputtering or low pressure plasma

Specific dry etch conditions depend on the etch tool (plasma or RIE), film thickness and resolution. An etch gas composition of 75–80% oxygen and 15–20% CF₄ is typical. Power density is usually 200 – 500 watts and vacuum pressure in the range of 100 – 500 mTorr.

After dry etching it may be necessary to clean patterned vias of residuals. Reverse sputtering or a low pressure oxygen plasma clean may be used for this process. This process will slightly roughen the surface of the film, which is desirable to enhance the adhesion of metals or the re-coating of subsequent polyimide layers.

Storage/Shelf Life

PI-2562 is stable at cleanroom temperatures (21°C) for about four weeks with no significant change in properties. When stored at -18°C, shelf-life is two years from date of manufacture.

Moisture contamination is detrimental to stability and must be avoided. Containers should be brought to room temperature before opening to avoid moisture condensation inside the bottle.

Table 1. Solution Properties of PI-2562

Test	Units	PI-2562
Solids	%	25.0 – 27.0
Viscosity	Poise	0.75 – 2.00
Chloride Content	Maximum ppm	5.0
Sodium or Iron Content	Maximum ppm	1.0
Potassium or Copper Content	Maximum ppm	0.5
Total Metals	Maximum ppm	10
Ash	Maximum %	0.10

Table 2. Cured Film Properties of PI-2562

	Units	PI-2562
Tensile Strength	kg/mm ²	11
Elongation	%	11
Modulus	kg/mm ²	175
Stress	dynes/cm ²	5.5 x 10 ⁸
Moisture Uptake	%	3
Dielectric Constant (at 1 kHz, 50% RH)		3.4
Dissipation Factor (at 1 kHz)		0.002
Coefficient of Thermal Expansion	ppm/°C	60
Glass transition temperature	°C	300
Decomposition Temperature	°C	550
Refractive Index		1.70

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Caution: Do not use in medical applications involving permanent implantation in the human body.