



September 2009

PROCESS GUIDE

HD-8930 Low Cure**Introduction**

HD-8930 is the newest technology for semiconductor stress buffer and packaging applications. Major benefits include:

- Lower temperature cure for fan out packaging and other low thermal budget devices
- Enhanced adhesion to eliminate cracking and delamination
- Improved chemical resistance to process and underfill chemistries
- Aqueous development chemistry for lower total process cost
- Positive acting for high resolution, fast photospeed and smooth sidewall formation
- Good mechanical, thermal and electrical properties for demanding applications
- Excellent storage and room temperature stability reduces wasted material
- Excellent copper compatibility allows successful use on various substrates.

Packaging and Storage

HD-8930 is supplied in 250g, 1 kilogram and 4 kilogram bottles. All material should be frozen upon receipt unless it is to be used immediately. Shelf life is one year from date of manufacture if stored at -18°C.

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 upon opening. HD-8930 is stable at cleanroom temperatures (21°C) for about four weeks with no significant change in properties. To avoid solvent loss, bottles should be kept tightly sealed when not in use.

Process

HD-8930 is a photo definable PBO (polybenzobisoxazole) precursor that can be patterned to cleanly resolve micron-scale patterns with controlled side-wall profiles without the need for photoresist. This reduces the number of process steps required for patterning overcoat layers, thus improving yields and reducing operating costs.

Setting-up an HD-8930 process requires the balancing of coating thickness, soft bake, exposure, development and cure conditions to give the desired final film thickness, resolution, and film properties. Standard broadband, G-Line, or I-line lithography tools and common TMAH-based developer tracks can be used.

Cleanroom Conditions

The processing of HD-8930 should be performed in standard cleanroom conditions under yellow light. Temperature and relative humidity conditions should be controlled for consistency ($\pm 2.0^\circ\text{C}$, $\pm 2\%$ RH) to obtain the best processing results.

Substrate Preparation

Substrates should be clean and dry prior to use. A dehydration bake of 150°C – 250°C for 120 – 240 seconds, followed by cooling to room temperature, will improve film adhesion. In some cases, oxygen plasma cleaning followed by a wet cleanup with an organic stripper solution will be needed to remove organic contamination.

Coating

HD-8930 can be coated onto a variety of metals, alloys, semiconductor and ceramic substrates. The material has a built-in adhesion promoter that should be adequate for most applications.

Table 1. Spin Speed Curve for HD-8930

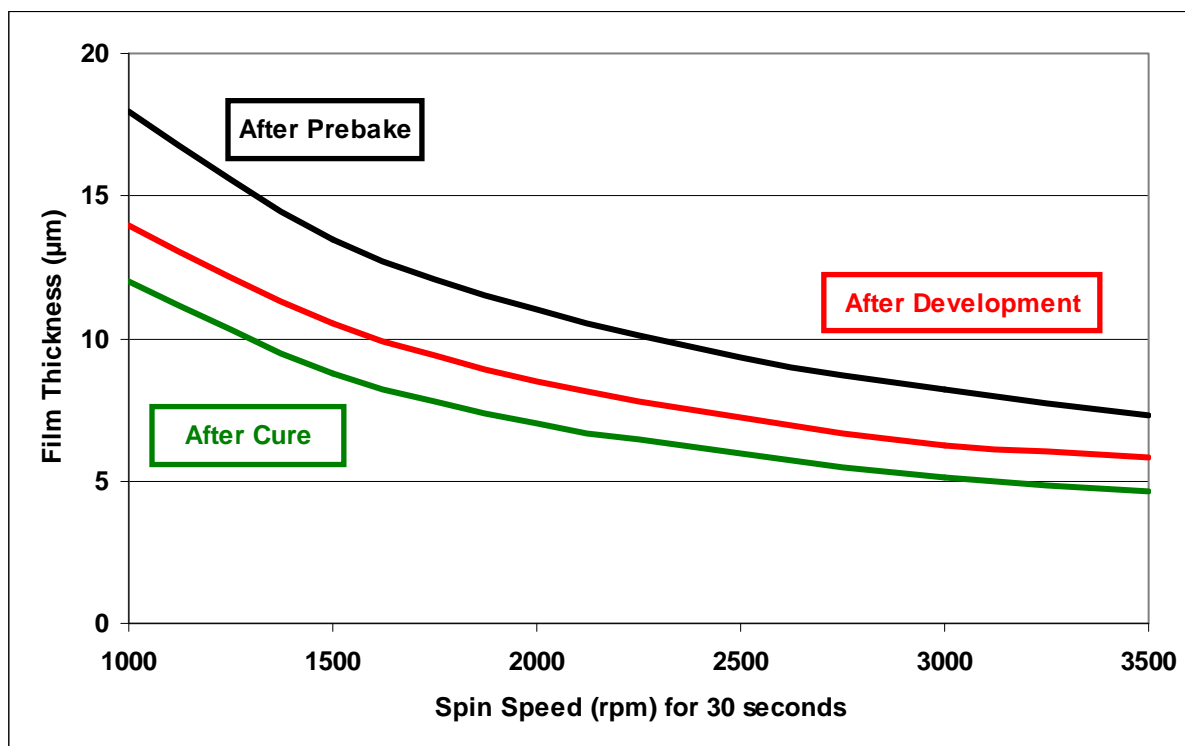


Table 1 illustrates the range of coating thicknesses obtainable from HD-8930. This is a guide, as different substrates, wafer size, surface topography, cleanroom conditions, soft bake conditions, development times and cure conditions will affect final cured film thickness.

The volume of HD-8930 dispensed should remain constant for each wafer to ensure wafer-to-wafer uniformity. Low spin speeds and/or short spin times can also impact film uniformity. Recommended spin speed range is 1000-3000rpm and spin time is 30-60 seconds.

An Edge Bead Removal (EBR) and Backside Rinse process may be added to the coating cycle to remove PBO precursor from the edge and back of the wafer prior to soft baking. PGMEA or cyclopentanone can be used. Optical EBR can also be applied.

Soft Bake

After the application of the PBO precursor, a bake process is required, usually on a single hot plate.

The purpose of this stage is to drive out most of the solvent in the film, leaving it dry to the touch and possible to handle in subsequent operations.

When setting-up a coating process, begin with setting the soft bake to 120°C for 180 seconds. If there is any film lifting after development, slowly increase the bake temperature to increase the adhesion. Temperature changes have larger effects but increasing bake duration can be used to fine tune the process. Higher bake temperatures and times will also require longer exposure and development times.

Exposure

Minimum exposure level is 200mj / cm². However, as mentioned above, increased soft bake temperatures and times will require higher exposure levels, typically 200 – 450mj / cm². The exposure must be just high enough to develop out, or clear, the exposed areas. Over-exposure can contribute to film lifting due to undercutting of the sidewalls. A depth of focus of 20% – 40% in to the film will better expose the bottom regions of the film and help it to develop out.

Development

For positive acting materials such as HD-8930, the develop step washes away the exposed areas, leaving the unexposed areas.

As shown in Table 1, the unexposed areas are etched by the developer and between 20 – 25% thickness loss is expected.

A double puddle development process is recommended. The key to getting a uniform developed film thickness is applying the developer solution by scanning the dispense head across the wafer as the developer solution is applied. Scan from edge to center and back to wet the wafer, then apply the puddle by scanning from edge to halfway to center and back. This avoids having the center of the wafer etch faster than the edge, causing the film to thin more at the center, resulting in poor film thickness after development.

A typical develop process is shown in the example and illustrates this technique. Each puddle will take between 30 – 55 seconds, again depending on the softbake conditions.

Cure

The objectives of a proper cure schedule are to remove residual solvent, complete the cyclization process to produce a PBO film and complete the adhesion process. Because all three of these actions can occur at different rates at a given temperature, the cure schedule is very important process step which impacts cured film quality and associated mechanical properties.

Curing is typically done as a batch process using programmable ovens or furnaces. Curing should be performed under a nitrogen atmosphere (oxygen concentration <100ppm). Some programmable ovens are designed to cure under a vacuum. A partial vacuum may be used with a nitrogen atmosphere.

Loading temperatures, ramp rates, soaks (intermediate holding temperatures), final cure temperature and cool down rate can be adjusted for optimum throughput and cured film properties. The lower the ramp rates (up and down), the lower the stress in the PBO. Film properties will vary with cure temperatures and time. Table 2 shows several curing temperatures and times and their affect on film properties. Curing

temperatures should be set at least 10C higher than any other subsequent processing temperature to ensure that there is no out-gassing from the film.

An oxygen plasma de-smear can also be employed to improve adhesion for subsequent processing steps.

Rework

Before curing, HD-8930 can be stripped with commercial cleaners commonly recommended for PBO precursor removal. Oxygen plasma etching can be used to remove both uncured precursor and cured PBO. After the plasma etch, an organic stripper should be used to remove trace organic contaminants that may degrade adhesion.

Example of Typical Process Conditions

Apply PBO 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 180sec

Expose PBO: 200 – 400mJ/cm²

Develop PBO

Developer: 0.26N TMAH

Rinse: DI water

Double Puddle Development Process:

- Apply (1000rpm) Scan Applicator Arm from Edge to Center and Back 3 seconds
- Apply (50rpm) Scan Arm From Edge to Halfway to Center and Back 3 seconds
- Puddle 37 seconds
- Apply (1000rpm) Scan Applicator Arm from Edge to Center and Back 3 seconds
- Apply (50rpm) Scan Arm From Edge to Halfway to Center and Back 3 seconds
- Puddle 37 seconds
- Rinse (1000rpm) 10 seconds
- Spin Dry (3000rpm) 15 seconds

Cure (in Nitrogen)

- Heat from RT to 100°C, ramp rate 6°C/min
- Hold 100°C, 30 minutes
- Heat to 200°C, ramp rate 1.5°C/min
- Hold at 200°C for 60 minutes
- Gradual cooling to RT

Table 2. Film Properties – Different Cure Conditions

			175°C	200°C	225°C	250°C
Mechanical Properties	Tensile Strength	MPa	170	170	170	170
	Elongation	%	85	80	80	80
	Modulus	GPa	1.9	1.8	1.8	1.7
Thermal Properties	Tg (TMA)	°C	240	240	245	245
	CTE	Ppm	80	80	80	80
	Temperature for 5% Weight Loss	°C	280	310	345	360
	Residual Stress	MPa	24	25	28	29
Electrical Properties	Dielectric Const	-		3.1		
	Volume Resistivity	Ω·cm		3X10 ¹⁶		

Cure Cycle – Ramp from RT to 100 °C in 10 minutes, hold 30 minutes, ramp to cure temperature 2-3°C per minute, hold at cure temperature for 60 minutes. N₂ Atmosphere (O₂ <100ppm).

Table 3. Chemical Resistance of Cured Films

Chemical	Temp °C	Time (min)		Cure Temperature for 1 Hour			
				175°C	200°C	225°C	250°C
NMP	25	60	Appearance	OK	OK	OK	OK
			Film Loss	None	None	None	None
	80	30	Appearance	OK	OK	OK	OK
			Film Loss	None	None	None	None
		60	Appearance	OK	OK	OK	OK
			Film Loss	3%	None	None	None
DMSO	80	30	Appearance	OK	OK	OK	OK
		Film Loss	None	None	None	None	
60	Appearance	OK	OK	OK	OK		
	Film Loss	4%	None	None	None		
PGMEA	25	30	Appearance	OK	OK	OK	OK
			Film Loss	None	None	None	None
Acetone	25	60	Appearance	OK	OK	OK	OK
			Film Loss	None	None	None	None
10% H ₂ SO ₄	25	15	Appearance	OK	OK	OK	OK
			Film Loss	None	None	None	None
2% HF	25	10	Appearance	OK	OK	OK	OK
			Film Loss	None	None	None	None
10% KOH	85	5	Appearance	Si Corrosion	Si Corrosion	Si Corrosion	Si Corrosion
			Film Loss	None	None	None	None
2.38% TMAH	25	15	Appearance	OK	OK	OK	OK
			Film Loss	None	None	None	None

Appearance – OK signifies no cracks, delamination or hazing.

Film Loss – None signifies less than 0.1µm.

Technical Service

HD MicroSystems has dedicated technical service facilities in Hitachi City, Japan and Parlin, New Jersey. Technical support personnel are available to work in-house on dedicated process tools, or on

location throughout the world to assist in process development or help resolve technical problems. For more information, contact your regional HD MicroSystems Technical Representative.

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