HD MicroSystems™
An Enterprise of Hitachi Chemical and DuPont Electronics

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PROCESS GUIDE

HD-8820 Aqueous Positive Polyimide

Introduction

HD-8820 is the latest technology for semiconductor stress buffer and packaging applications. Major benefits include:

- Aqueous development chemistry for lower total process cost
- Positive acting for high resolution
- Specially formulated for fast photospeed to increase throughput in Lithography
- Good mechanical and thermal properties to hold up in the most demanding applications
- Low moisture uptake and good dielectric properties to protect vital circuitry
- Wide processing window reduces in process monitoring and adjustments
- Excellent storage and room temperature stability reduces wasted material
- Excellent copper compatibility allows successful use on various substrates.

Packaging and Storage

HD-8820 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 twelve months from date of manufacture if stored at -18^{o}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-8820 is stable at cleanroom temperatures (21^{o}C) for about two weeks with no significant change in properties. To avoid solvent loss, bottles should be kept tightly sealed when not in use.

Process

HD-8820 is a photodefinable polyimide 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-8820 process requires the balancing of coating thickness, softbake, 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-8820 should be performed in standard cleanroom conditions under yellow light. Temperature and relative humidity conditions should be controlled for consistency (±2.0^{o}C, ±2% RH) to obtain the best processing results.

Substrate Preparation

Substrates should be clean and dry prior to use. A dehydration bake of 150 ^{o}C – 250 ^{o}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 such as Tokyo Ohka S-1006 will be needed to remove organic contamination.

Coating

HD-8820 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. For additional adhesion, the silane adhesion promoter VM-651 or VM-652 can be applied prior to coating the HD-8820.

Table 1. Spin Speed Curve for HD-8820

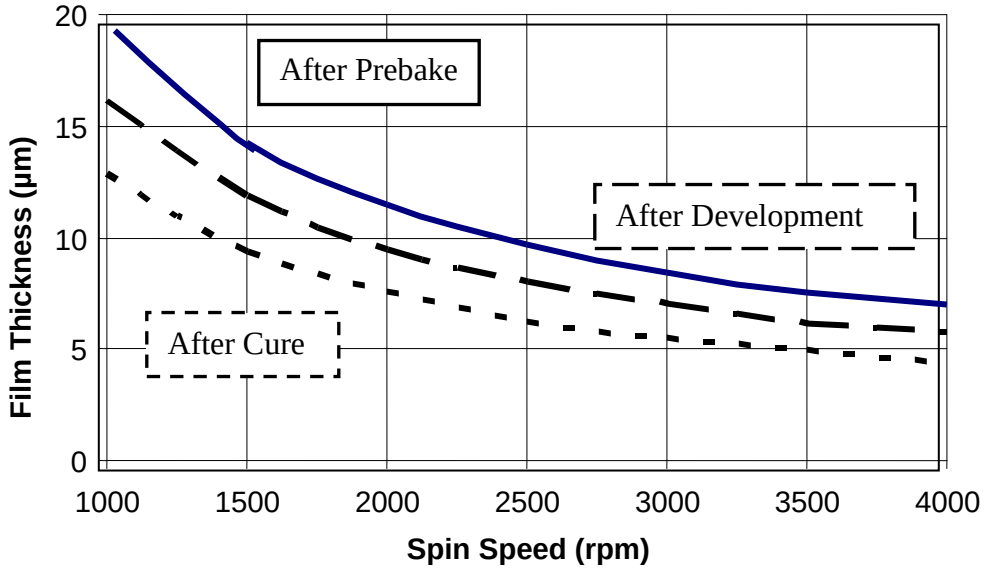

Table 1 illustrates the range of coating thicknesses obtainable from HD-8820. This is a guide, as different substrates, wafer size, surface topography, cleanroom conditions, softbake conditions, development times and cure conditions will affect final cured film thickness.

The volume of HD-8820 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 1000-4000rpm 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 polyimide from the edge and back of the wafer prior to softbaking. PGMEA, N-Butly-acetate (NBA) and cyclopentanone can be used. Optical EBR can also be applied.

Soft Bake

After the application of the polyimide, 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 softbake to 120^{o}C for 180 seconds. If there is any polyimide 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 280mj / cm^2. However, as mentioned above, increased softbake temperatures and times will require higher exposure levels, typically 280 – 500mj / cm^2. 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 photodefinable polyimides such as HD-8820, 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 35 – 60 seconds, again depending on the softbake conditions.

Cure

The objectives of a proper cure schedule are to remove residual solvent, complete the imidization process 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 polyimide. Film properties will vary with cure temperatures and time. Table 2 shows several curing temperatures and times and their affect on film properties. Curing below 280°C will require hold times of between 2 – 4 hours to obtain acceptable 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.

Before curing, HD-8820 can be stripped with commercial cleaners commonly recommended for polyimide removal. Oxygen plasma etching can be used to remove both uncured and cured polyimide. An oxygen plasma de-smear can also be employed to improve adhesion for subsequent processing steps.

Rework

Before Curing, HD-8820 can be stripped with commercial cleaners commonly recommended for polyimide removal. Oxygen plasma etching can be used to remove both uncured and cured polyimide. After the plasma etch, an organic stripper should be used to remove trace organic contaminates that may degrade adhesion.

Example of Typical Process Conditions

Optional Adhesion Promoter
(Pyralin® 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 180sec

Expose Photoresist: 280 – 400mJ/cm^2

Develop Polyimide

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 150°C, ramp rate 4°C/min
- Heat to 320°C, ramp rate 2.5°C/min
- Hold at 320°C for 60 minutes
- Gradual cooling to RT

Table 2. Film Properties – Different Cure Conditions

			250°C 2 Hr	250°C 4 Hr	280°C 1 Hr	300°C 1 Hr	320°C 1 Hr	350°C 1 Hr	350°C
			Furnace[1]						Hot plate[2]
Mechanical Properties	Tensile Strength	MPa	114	122	133	139	167	168	149
	Elongation	%	25	78	95	102	100	87	66
	Modulus	GPa	2.0	2.2	2.3	2.1	2.0	2.0	2.6
Thermal Properties	Tg (TMA)	°C	270	-	257	278	298	299	306
	(CTE)	ppm	55	-	61	60	64	67	52
	Temperature for 1% Weight Loss	°C	370	-	375	386	399	397	393
	Temperature for 5% Weight Loss	°C	471	-	471	479	491	482	476

1. Furnace – Ramp from 150 °C to Cure Temp in 90 minutes, 10µm Film, N_2 Atmosphere (O_2 <100ppm)
2. Hot plate – 160 °C /180sec. + 350 °C /420sec. +120 °C /60sec, 10µm Film, Air Atmosphere

Table 3. Other Cured Film Properties (Cured at 320°C, 1 hour)

Electrical Properties	Dielectric Constant	2.94	
	Dissipation Factor	0.0089	
	Dielectric Strength	470	kV/mm
	Volume Resistivity	$3.4X10^{16}$	Ω·cm
	Residual Stress	37	MPa
	Moisture Uptake	<0.5	%

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.

United States

HD MicroSystems

250 Cheesequake Road
Parlin, NJ 08859-1241
800-346-5656 ext. 13, 14 (Phone)
732-613-2502 (Fax)

10080 North Wolfe Road,
SW3-200
Cupertino, CA 95014
800-346-5656 ext. 11 (Phone)
408-996-0508 (Fax)

Japan

HD MicroSystems, Ltd.

Korakuen Building 14F
4-1, Koishikawa 1-chome,
Bunkyo-ku
Tokyo 112-0002, Japan
81-3-3868-8124 (Phone)
81-3-3868-8126 (Fax)

Europe

HD MicroSystems GmbH

Hugenottenallee 175
63263 Neu-Isenburg
Germany
49-6102-18-1823 (Phone)
49-6102-18-1824 (Fax)

Internet

www.hdmicrosystems.com