



Contrast Enhancement Materials

CEM 365HR

INTRODUCTION

In 1989 Shin-Etsu Chemical acquired MicroSi, Inc. including their Contrast Enhancement Material (CEM) technology business*. A concentrated effort in the technology advancement of a CEM led to the development of an aqueous based and completely water soluble material. CEM 365HR is targeted for high NA I-line applications and feature sizes below approximately 0.50 μ .

*Contrast Enhancement Lithography was developed to extend the limit of practical resolution in the field of Photolithography.

CEM 365HR - PRODUCT PROPERTIES AND PROCESSING GUIDELINES

Contrast enhancement is a microlithography technique which extends the practical limits of optical lithography systems. This improvement in resolution, depth of focus and reduced interference, allows the fabrication of new and denser integrated circuits without the required capital equipment investment.

Significant benefits of contrast enhancement can be recognized from the following performance features:

- Increase Depth of Focus Latitude
- Reduced Linewidth Change Over Steps
- Extends Resolution Limits
- Generates Vertical Resist Profiles
- Increases Develop/Exposure Latitude
- Reduces Proximity and Interference Effects
- Increased integrity in high aspect ratio features
- Simple/Low defect Process

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GENERAL DESCRIPTION

The Contrast Enhancement Material (CEM) Process is a unique photolithography technique designed to extend and enhance both the process latitude and resolution limits of optical lithography systems. The purpose of this guideline is to provide information on the theory, characteristics, and use of CEM 365HR

CEM THEORY

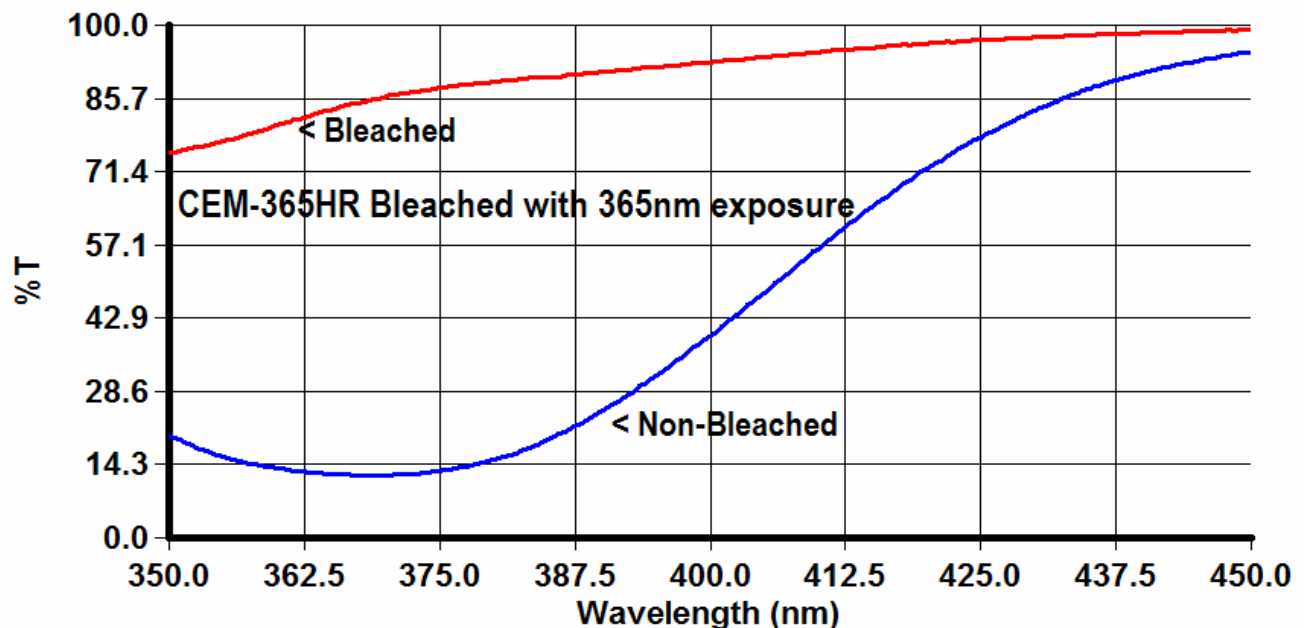
CEM is a photo bleachable solution, which is initially opaque to the exposure wavelength(s) but becomes nearly transparent upon exposure. Figure 1 shows the spectral transmission characteristics of CEM 365HR. The Contrast Enhancement Material is spin coated over softbaked positive resist. When the aerial image of a mask incident upon the CEM layer, the regions of highest intensity corresponding to the clear areas of the mask, are bleached at a faster rate than the lower intensity gray and dark areas on the mask. By adjusting the bleaching dynamics so that the absorption of the CEM layer is sufficiently high and the photospeeds of the CEM and resist layers are properly matched, it is possible to completely expose the underlying photoresist in the light areas before the CEM is bleached through in the dark areas. Thus, during the exposure an in-situ conformal contact mask is formed in the CEM layer. The net effect is a higher contrast level of the aerial image used to expose the photoresist (Figure 2).

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Other conditions such as light scattering and second order aerial image effects shown in Figure 2 also contribute to degradation of desired photoresist performance. With the proper match of CEM and exposure parameters the CEM layer will absorb, in the dark areas, all the light from light scattering and second order aerial image effects before they reach the resist surface. The benefit is much straighter or vertical sidewalls and the elimination of rounding or pointed edges at the tops of features.

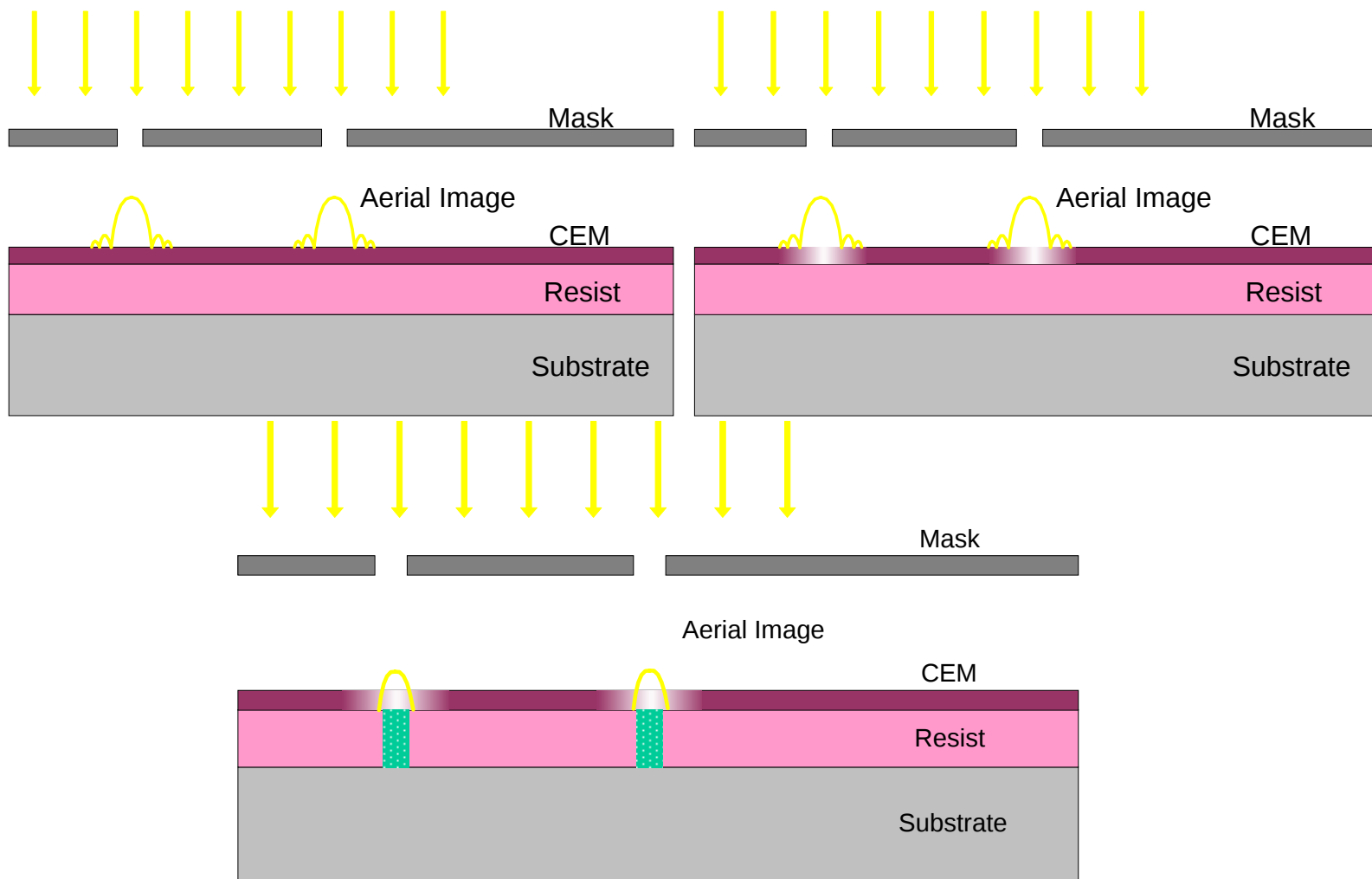
Figure 1: CEM 365HR Spectral Transmission Characteristics



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Figure 2: CEM Theory



MATERIAL PROPERTIES

Solids	8.5 ± 1.0 %
Viscosity @ 25 Deg C	2.0 ± 0.5 cstks
Refractive index	1.59
Film thickness	1,500 ± 200 Å @ 4,000 rpm
Appearance	Clear, Yellow
Initial transmission (365 nm)	< 16.5 %
Final transmission (365 nm)	> 83.5 %
Cauchy Coefficients	
N ₀	1.551
N ₁	141.9
N ₂ , K ₀ , K ₁ , K ₂	0.000

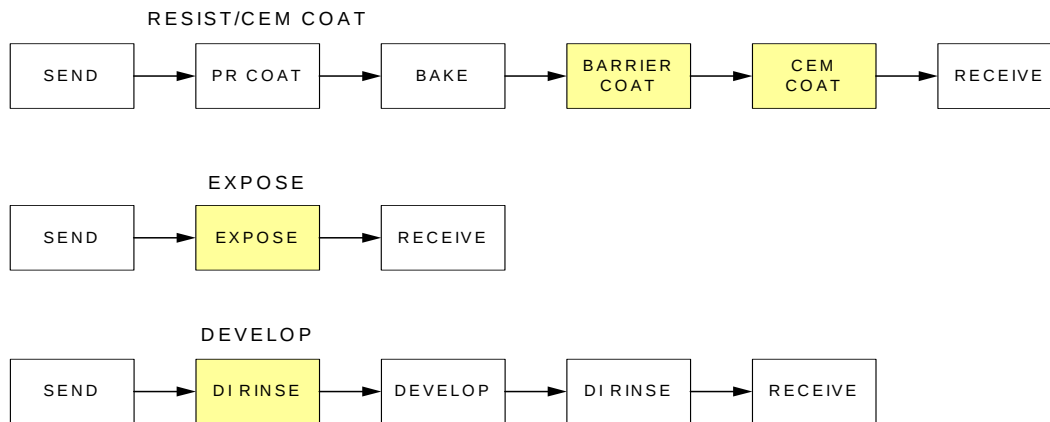
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CEM PROCESS CONDITIONS

Figure 3 illustrates the photolithography steps in using CEM. Note that, the CEM process adds only one simple step to the normal positive photoresist processing sequence.

Figure 3: Process Steps



Sequence of steps in the Contrast Enhancement Process

1. Spin coat positive photoresist on primed wafers.
2. Softbake photoresist according to standard process.
3. Spin coat CEM (Barrier Coat not required with CEM 365HR)
4. Expose wafer
5. Strip CEM using a DI water pre-wet
6. Post Exposure bake (if applicable)
7. Develop photoresist according to standard process.

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CEM COATING

The most common dispensing method is dispensing directly from the bottle of Nowpack using a photoresist pump. For best results, point of use filtration is recommended.

The following CEM 365HR spin coat program is recommended to yield excellent thickness uniformities ($< 50 \text{ \AA}$ variation across the wafer).

1. CEM 365HR static dispense.
2. Spread for 2 seconds at 500 rpm.
3. Ramp at 10,000-rpm/sec minimum to final spin speed (4,000 rpm nominal).
4. Spin dry for 30 seconds (minimum)

Approximate dispense volume of CEM 365HR by wafer size.

3" & 4"	1.0-1.5 ml
5" & 6"	2.0-2.5 ml
8"	3.0-3.5 ml

The resulting film will be somewhat tacky, but at no time should the film be subjected to a softbake process including momentary hot plate contact.

The above coating sequence should yield a film thickness approximately 1,500 $\text{\AA}$. A thinner or thicker CEM layer may prove to be optimum for certain resists and applications, and should be characterized by the user (See Figure 4).

To measure the thickness of CEM 365HR

1. Coat clean bare silicon with CEM 365HR using the above procedure.
2. Bleach wafer by exposing to UV source for a minimum of 30 seconds.
3. Immediately measure thickness using a refractive index of 1.59.

Note: It is important that the film is completely bleached. Partially bleached films can contribute to high readings (up to +200 $\text{\AA}$) and poor uniformity.

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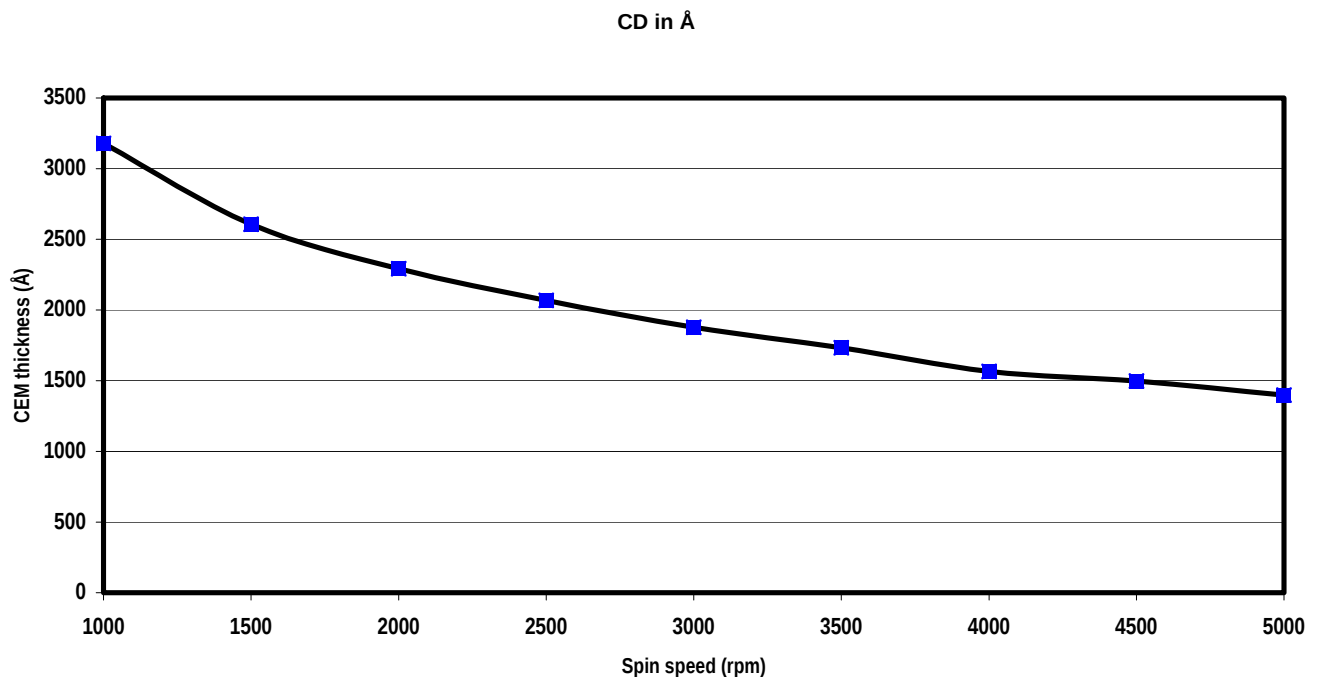
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Good linewidth control is dependent upon the uniformity of the CEM layer thickness. It is important to use a photoresist thickness that provides adequate planarization of the topography being coated. Normally this is 2 to 2.5 times the greatest step height. One of the benefits of CEM is that it provides a high aspect ratio. Therefore, thicker photoresist films can be used with no loss in resolution.

Coater exhaust also can contribute to coat uniformity. For best results, the exhaust should be adjusted for the low viscosity and high vapor pressure of CEM 365HR.

Note: It is recommended the filtration media is polyethersulfone with a mesh size of 0.1um.

Figure 4: CEM 365HR Thickness vs. Spin Speed



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CEM 365HR EXPOSURE

CEM 365HR was developed for 365 nm, high NA I-line exposure tools.

As with conventional resists, a focus/exposure matrix should be run to determine the parameters which will yield optimum results.

The exposure required will be approximately 30% to 100% higher and the center of focus will shift from the center to the top of a standard photoresist process. The increase in dosage is dependent on the photoresist and thickness, CD's being printed and the exposure tool.

CEM 365HR STRIP/DEVELOPMENT

CEM 365HR is a water strippable formulation. A develop pre-wet is all that is necessary to strip the CEM layer. CEM must be stripped prior to PEB.

1. Spin wafer at 1,000 rpm.
2. DI water rinse 5-10 seconds @ 1,000 rpm.
3. Start standard development process immediately (no spin dry after strip required).
4. DI water flow rate should be ≥ 10 ml/sec.

CEM 365HR is aqueous based and is compatible with developer.

CEM 365HR PRODUCT HANDLING AND STORAGE PROCEDURES

Handling Precautions

CEM 365HR is light sensitive and should only be processed under yellow light. Avoid contact with skin and eyes. Handle with care. Wear chemical goggles, rubber gloves and protective clothing.

Storage

Store in sealed, original containers, in a dry area, away from light. Cold storage at 0 to 5 ° C is recommended to insure optimum quality and shelf life. CEM 365HR should be allowed to stabilize at ambient temperature before use.

Waste disposal

CEM 365HR is soluble in alkaline water. The developers used for positive photoresist are alkaline. The CEM waste can be treated the same as the photoresist developer. All disposal is to be done in accordance with Federal, State and local regulations.

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FIRST AID FOR CEM 365HR

Take action as follows:

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|------------------|--|
| If Eye contact: | Flush with water for at least 15 minutes. Contact physician. |
| If Skin contact: | Wash affected areas with soap and water. Remove contaminated clothing. If irritation persists, contact a physician. Wash clothing before re-use. |
| If Ingested: | If swallowed do not induce vomiting. Give large quantities of water and seek emergency attention immediately. Never give anything by mouth to an unconscious person. |

Refer to Safety Data Sheets for more information

Shin-Etsu MicroSi

Shin-Etsu MicroSi, Inc. is a wholly owned subsidiary of Shin-Etsu Chemical Co., Ltd., a global leader in research, development and the manufacture of chemicals used in the semiconductor industry. From its headquarters in Phoenix, Arizona, Shin-Etsu MicroSi provides high performance products and materials including:

- Thermal Interface Materials
- KJR Liquid Coating Materials
- Contrast Enhancement Materials
- Mask Blanks
- PBN Crucibles
- Photoresists / Developers
- Quartz Substrates & Wafers
- Liquid Underfill Materials
- Barrier Coats
- Pellicles
- Flexible Copper Laminate
- Epoxy Molding Compounds
- Adhesion Promoters

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