DisChem
CHEMISTRY FOR
ADVANCED LITHOGRAPHY

# SURPASS

**MICROLITHOGRAPHY ADHESION PROMOTER / PRIMING AGENT**

Document ID: SPXT1704

SurPass is a waterborne cationic organic surface active agent designed to promote adhesion and improve overall coating quality on a broad range of substrate materials used in microlithography. SurPass promotes photoresist adhesion through cationic interaction and modification of the substrate surface energy.

## Advantages in Lithographic Processing:

- *Improved microlithographic resist, resist, polymer, and HSQ adhesion on a broad range of substrate materials.*
- *Improved patterned resist mould to copper seed layer for subsequent electroforming operation.*
- *Increased adhesion of evaporated metals to substrate materials*
- *Improved removal of critical substrate contaminants*
- *Improved adhesion may allow for reduction of EBL exposure energy for minimizing BSE emission reducing exposure time*
- *Reduced z-potential for improved coating properties*
- *May eliminate the need for thermally matched glass*
- *Replaces pre-wetting solvents*
- *Eliminates need for substrate dehydration bake prior to processing*
- *Non-Hazardous waterborne formulation.*
- *No VOC or hazardous breakdown products*

## Substrate compatibility

SurPass has demonstrates excellent adhesion properties on a wide range of substrate materials, including glass, silicon nitride, metals, metal oxides, ceramics (ruby, sapphire) and plastics (PET).

## Resist and Polymer Compatibility

SurPass has shown compatibility with most positive and negative resist and polymer formulations, providing excellent adhesion when used in conjunction phenolic resin Novolak resist (DNQ/Novolac/ma-N2400/Shipley1800), poly methyl methacrylate (PMMA), poly methyl glutarimide (PMGI), epoxy based polymer (SU8), polyimide, electron beam resist (including HSQ), chemically and non-chemically amplified photoresist.

## Enhanced Coating Properties

In addition to promoting adhesion, SurPass modifies the available surface energy to provide a more uniform coating surface for improved resist flow . Evidence suggests that SurPass may be used in polyimide processing to both improve performance and reduce material consumption through reduced Zeta potential. SurPass provides improved coating flow and uniformity even where resist / polymer adhesion is not an issue.

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# SurPass Formulations and Properties

SurPass is manufactured in two versions designated as SurPass 3000 (P/N SP3) and SurPass 4000. (SP4) Both variants of SurPass are waterborne, non-hazardous, and contain no volatile organic compounds (VOC's) and produce no ammonia or other breakdown products during application.

**SurPass 3000:** Waterborne, mildly acidic (2.5-3.5) and contains a cleaning and surfactant package for removal of critical contaminants while optimizing surface energy for improved resist adhesion. May be used as an ultrasonic cleaning solution for combining cleaning with improved adhesion. Water rinse after application may be followed by IPA rinse to minimize dry time.

**SurPass 4000:** Waterborne, slightly alkaline (9.0-10.0) and contains no additives. Broad range substrate - resist compatibility. Rinse with water or IPA. Excellent for improving adhesion of patterned resist mould on copper seed layer for subsequent electroplating.

## Selection of Appropriate SurPass Primer:

There are several variables to consider when selecting the SurPass formula best suited to a specific process. These include the type of resist used, the substrate surface material, and post resist exposure requirements. In general, SurPass 3000 is recommended for use with epoxy resists (SU-8) and HSQ e-beam resist, while SurPass 4000 is ideal for promoting adhesion of novolac [1] resists (ma-N 1400, ma-N 2400, Shipley 1800, etc.). Initial evaluation of SurPass primers will ideally include comparison of both SurPass 3000 and SurPass 4000 to account for process variables that may be further optimized by SurPass.

## Use and Application

SurPass may be applied by spin coating, dip / immersion, spray, etc. or any other means that allows for coat - rinse - dry cycle, followed by application of the resist. SurPass 3000 allows for bulk processing and can be used with ultrasonic agitation to combine final cleaning with adhesion priming. SurPass eliminates the need for a substrate dehydration bake prior to processing.

**Spray / Dispense / Spin Coat Application:**

| Process step | SurPass 3000 | SurPass 4000 |
|---|---|---|
| Spin coat | 3000 rpm<br>30 seconds | |
| Rinse | Water (SU-8 IPA) | Water or IPA |
| Dry | Spin dry or $N_2$ blow | |
| Apply Resist | Epoxy resist (SU-8),<br>HSQ, Polymer, PR | Novolac Based Resist |

**Immersion / Ultrasonic / Batch Processing:**

1. Clean substrate, normal cycle. Separate wet chemical cleaning can be eliminated when using SurPass 3000 with ultrasonic agitation. No dehydration bake is needed.
2. Immerse substrates in SurPass bath for 30-60 seconds.
3. DI water rinse substrates for 30-60 seconds.
4. Dry[2] by spin or nitrogen blow.

[1] Phenol-formaldehyde (PE) resins
[2] Drying time may be reduced by rinsing with isopropyl alcohol after the water rinse.

**Equipment Requirements:**

Tanks: Polypropylene of high-density polyethylene is recommended.
Filters: Use hydrophilic ultra high-density polyethylene or equivalent is recommended. Most filters designed for use with D.I. water will meet the requirements of SurPass. SurPass is pre-filtered to 0.45 µm

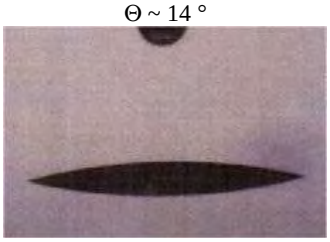
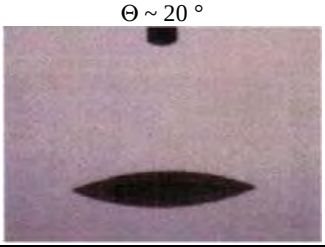
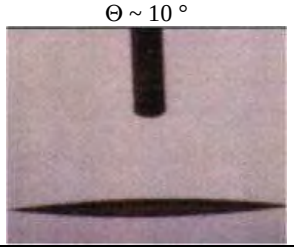
**Waste Treatment:**

SurPass is waterborne, non-hazardous and contains his contains biodegradable surfactants. Always dispose of treated wastes in accordance with local, state and federal regulations. See the product MSDS for further information on regulated constituents.

## Background and Performance Data

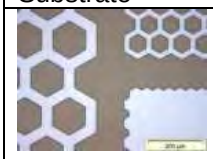
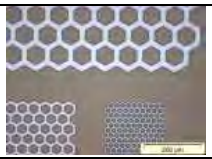
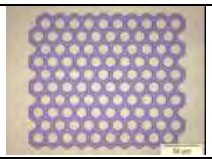
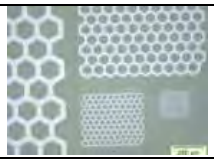
**Surface Energy**

The effect of SurPass on substrate surface energy is demonstrated by measuring contact angle on treated and untreated Si wafers.

| | | |
|---|---|---|
| Si - Untreated<br>Θ ~ 14 °<br>  | Si + $0_2$ Plasma<br>Θ ~ 20 °<br>  | Si + $0_2$ Plasma + Dehydration Bake<br>Θ ~ 10 °<br>  |
| Si + SurPass 3000 + Water Rinse<br>Θ ~ 25 °<br>  | Si + SurPass 4000 + Water Rinse<br>Θ ~ 27°<br>  | Si + SurPass 4000 + IPA Rinse<br>Θ ~ 28 °<br>  |

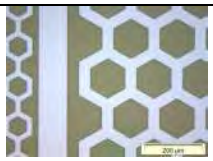
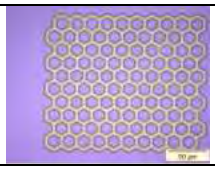
**Positive Tone DNQ / Novolac Resist** (ma-P1200 series)

**ma-P 1200**, Film thickness = 7.5 µm, development in 0.22 to 0.26N TMAH
Images provide courtesy of *micro resist technology* GmbH, Berlin, Germany

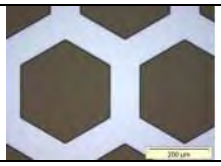
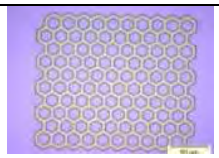
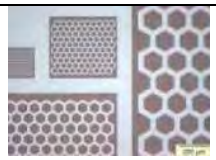
| Control, Silicon Substrate | Si + SurPass 4000 | $SiO_2$ + SurPass 4000 | Glass + SurPass 40000 | GaP + SurPass 4000 | Cu + SurPass 4000 |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| Bad adhesion of small patterns | Excellent adhesion | Excellent adhesion | Excellent adhesion | Excellent adhesion | Excellent adhesion |

## Negative Tone Aromatic Bisazide / Novolac Resist (ma-N 400, ma-N 1400 series)

**ma-N 1400**, Film thickness 1 µm, developed in ma-D533/S or 0.363 N TMAH

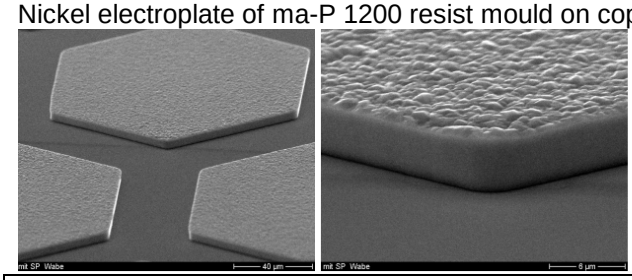
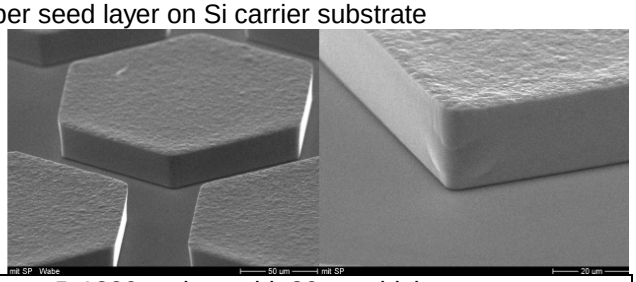
| Control, Silicon Substrate | Si + SurPass 4000 | $SiO_2$ + SurPass 4000 | Glass + SurPass 40000 | GaP + SurPass 4000 |
|---|---|---|---|---|
|  |  |  |  |  |
| Bad adhesion | Excellent adhesion | Excellent adhesion | Excellent adhesion | Excellent adhesion |

**ma-N 400**, Film thickness = 7.5 µm, developed in ma-D 332S or 0.2N NaOH or 0.275N TMAH

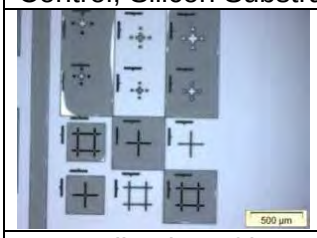
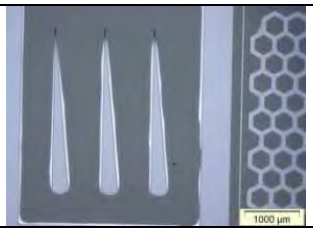
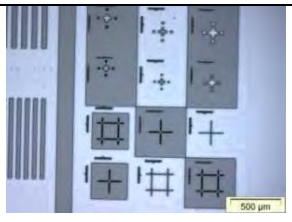
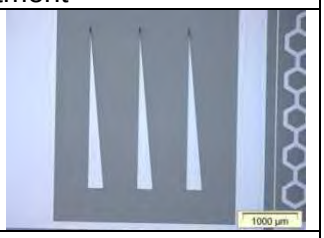
| Control, Silicon Substrate | Si + SurPass 4000 | $SiO_2$ + SurPass 4000 | Glass + SurPass 40000 | GaP + SurPass 4000 |
|---|---|---|---|---|
|  |  |  |  |  |
| Bad adhesion | Excellent adhesion | Excellent adhesion | Excellent adhesion | Excellent adhesion |

## Nickel Electroplate on Positive Tone DNQ / Novolac Resist (ma-P1200 series)

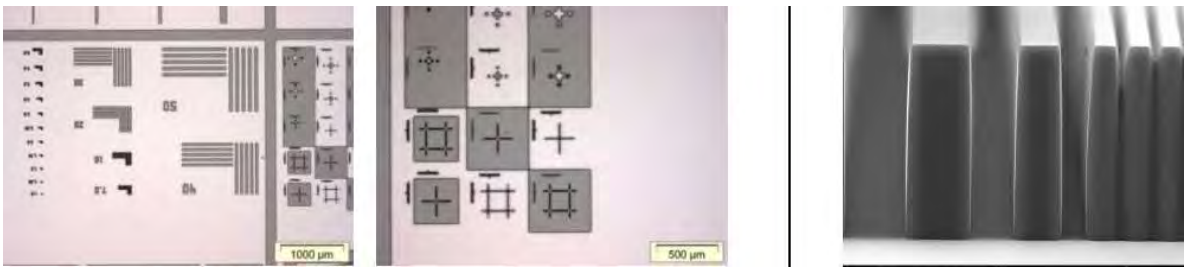
Nickel electroplate of ma-P 1200 resist mould on copper seed layer on Si carrier substrate

| | |
|---|---|
|  |  |
| ma-P 1200 resist mold, 7.5 µm thick.<br>Ni electroplated to 5 µm thickness on<br>Cu seed layer | ma-P 1200 resist mold, 30 µm thick.<br>Ni electroplated to 25 µm thickness on<br>Cu seed layer |

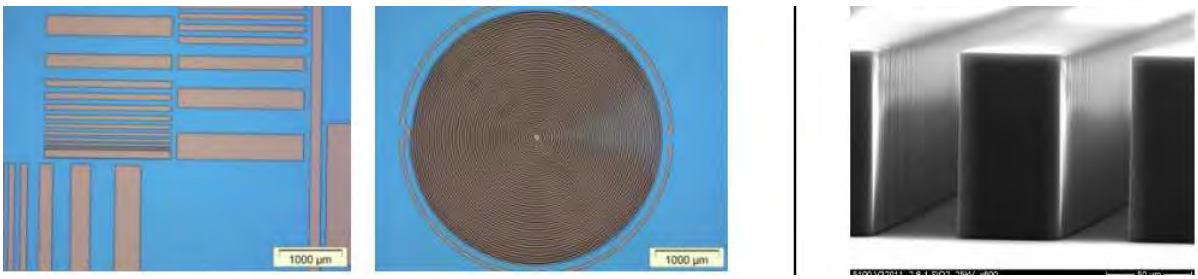
## Epoxy Resist (SU-8)

| Control, Silicon Substrate | | Si+ SurPass 3000 treatment | |
|---|---|---|---|
|  |  |  |  |
| Poor adhesion of large patterns | | Excellent Adhesion | |

## SU-8 adhesion on various substrate materials

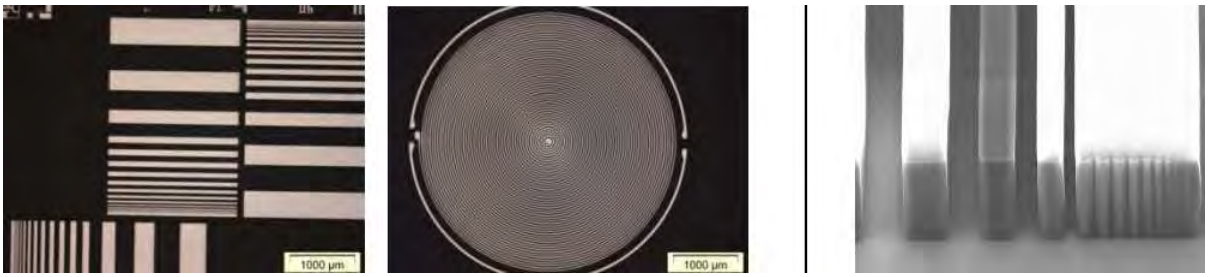



SU-8 epoxy resist on Si substrate treated with SurPass 3000

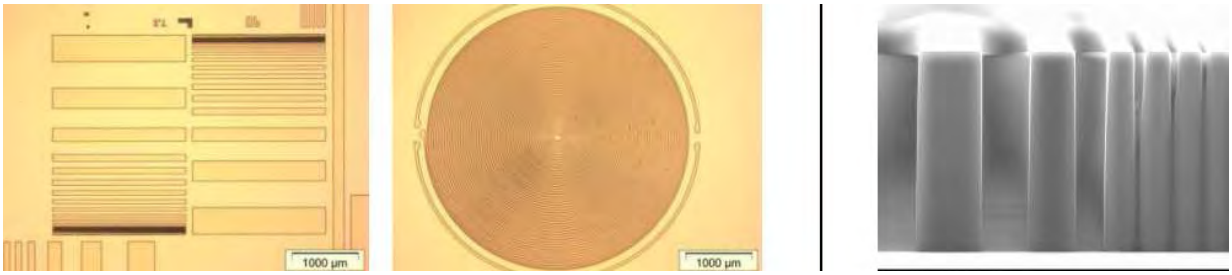



SU-8 epoxy resist on $SiO_2$ substrate treated with SurPass 3000


SU-8 epoxy resist on Glass substrate treated with SurPass 3000




SU-8 epoxy resist on $TiO_x$ substrate treated with SurPass 3000




SU-8 epoxy resist on Cr/Au on Si substrate treated with SurPass 3000

## Improved Adhesion of HSQ Electron Beam Resist

SurPass greatly improves electron beam resist adhesion on III, IV, V metal oxide substrates, allowing for reduced exposure energy and improved process latitude for small and large lithographic features.

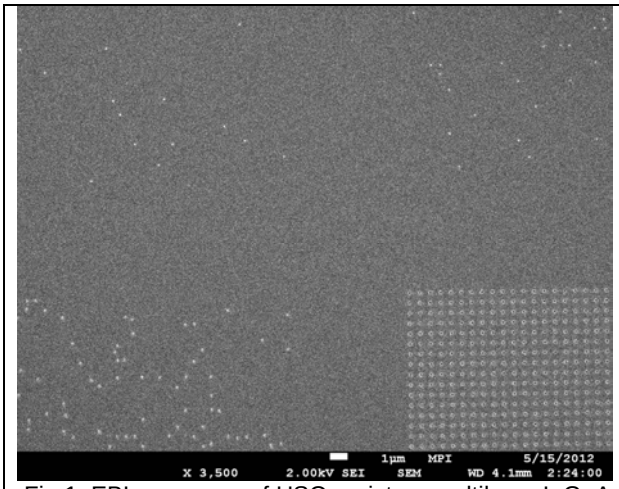



Fig 1: EBL exposure of HSQ resist on multilayer InGaAs **No Treatment** prior to application of resist

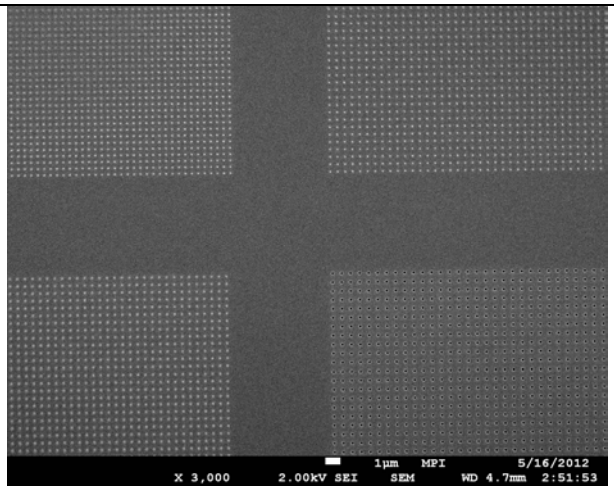



Fig 2: EBL exposure of HSQ resist on multilayer InGaAs **Treated with SurPass 3000** prior to application of HSQ resist

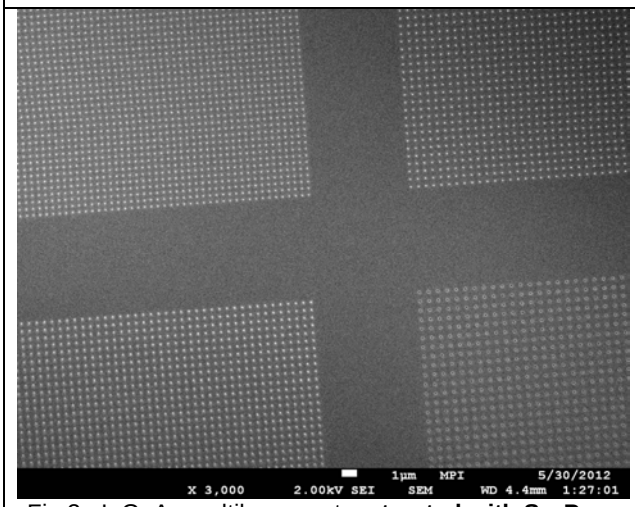



Fig 3: InGaAs multilayer system **treated with SurPass 3000 prior** to application HSQ resist. **Exposure dose reduced by factor of four**

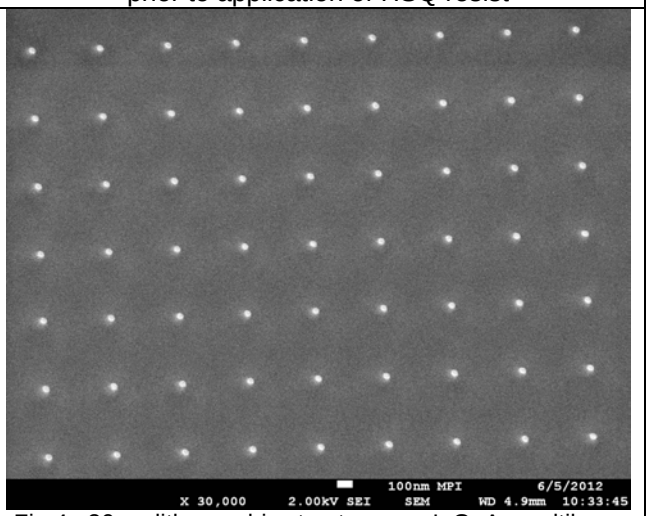



Fig 4 : 30nm lithographic structures on InGaAs multilayer system **treated with SurPass 3000** prior to application of HSQ. **Exposure dose reduced by factor of four.**

An array consisting of four quadrants with arrays of columns with 30nm, 50nm 100nm and 200nm were created using electron beam lithography. The columns were made using HSQ resist on a multilayer InGaAs system. This mask created in HSQ resist was transferred by RIE (Reactive Ion Etching) into the substrate. Wafers treated with SurPass 3000 e-beam lithography demonstrated a dramatic improvement in adhesion of the resist to the wafer, while allowing the electron beam dose to be reduced by a factor of four.

The complete findings of this study were published at the SPIE 2013 Advanced Lithography Advances in Resist Materials and Processing Technology Conference (Paper Number: 8682-77) Electron Dose Reduction Through Improved Adhesionby Cationic Organic Material with HSQ Resist on an InGaAs Multilayer System on GaAs Substrate, Erfurth, Wilfried. Max-Planck-Institute of Microstructure Physics, Halle (Saale), Germany / Thompson, Andrew. DisChem, Inc. Ridgway, PA, USA / Ünal, Nezih. GenISys GmbH, Munich, Germany

## Novel Uses And Applications

### Electro-Polish Pre-Step

SurPass 4000 has been shown to greatly improve uniformity in electro polishing of stainless steel when used as a pre-step after solvent cleaning.

### Acrylic Molding Pre-Step

SurPass 3000 may be used prepare stainless steel for molding / embedding in acrylic. Pre-treatment with SurPass increases acrylic adhesion to stainless steel while preventing air bubble formation.

## Product Availability and Ordering Information

SurPass is provided ready to use and pre-filtered to 0.45 microns. SurPass is also available in concentrated form, SurPass 3000DX.

**Product Inquiries & Ordering Information:**

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**Product Codes / Description:**

SP301- SurPass 3000, 1 gallon (3.8L) bottle
SP304 - SurPass 3000, case of 4 X 1 gallon bottles
SP3DX - SurPass 3000DX Concentrate (10X), 1 gallon bottle

SP401- SurPass 4000, 1 gallon bottle
SP404 - SurPass 4000, case of 4 X 1 gallon bottles
SP4DX - SurPass 4000DX Concentrate (10X), 1 gallon bottle

Note: 1 gallon = 3.785 Liters

***This product is protected by US and international patents***

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CHEMISTRY FOR ADVANCED LITHOGRAPHY

### DisChem Mission Statement

DisChem is dedicated to serving the needs of the Advanced Lithography community by providing innovative chemical solutions.

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