Mix&Match Process

(ASML/GCAWS6 Steppers)

1.0 Title

Mix&Match Process

2.0 Purpose

A new Mix&Match process is presented on the 6" ASML/GCAWS6 steppers, enabling members to use both lithography tools in the same run. New CAD templates and stepper jobs were released for this process.

3.0 Scope

A successful Mix&Match process was tested in the CMOS180 run which enabled the use of both 6" steppers in the lithography process. We assigned the critical layers to the DUV ASML (5x reducing) stepper, while non-critical layers were exposed on the standard I-line based GCAWS6 (5x reduction) stepper.

4.0 Applicable Documents

Revision History

4.1 SVG 8800 6" Coat Track, Chapter 4.24 of the lab manual

4.2 Mask Making for ASML Wafer Stepper (6"), Chapter 3.1 of the lab manual

4.3 GCA 3600 Pattern Generator, Chapter 3.3 – Appendix 12.2 of the lab manual.

5.0 Definitions & Process Terminology

ASML Reticle: 6"×6" quartz plate at specific thickness (0.25 or 0.15 or 0.12 inches).

Flash Field: Exposed area at each exposure step (same for all layers in a particular job).

Stepper Job (ASML): A job or recipe that defines the flash field size, and stepping pattern for the stepper.

DUV Resist: A photosensitive material sensitive to DUV light (λ = 248 nm or 193 nm or 157 nm). The Cymer laser used in the 5500/90 ASML stepper generates light at 248 nm wavelength.

PM Mark: A diffraction grating (4 quadrant of parallel line and spaces) used for accurately aligning the wafer to the reticle by the ASML.

Job (GCAWS6): File containing a description of all reticle changes, exposure sequences and stage motions, which constitute the pattern of images to be projected onto the wafers specified by the SPEC (for new jobs) or EDIT commands (to modify existing jobs). A Job consists of one or more **passes**.

Pass: Describes placement of exposures on a wafer from a single reticle. During an **array pass,** a wafer is covered with exposures, except for those locations specified as **dropouts**. During a **plug pass** exposures are made only at specified locations.

DSW: Direct Step Wafer

AWH: Automatic Wafer Handler

RMS: Reticle Management System

FLOOR: Slot number on the reticle cassette elevator

6.0 Safety

N/A

7.0 Statistical/Process Data

N/A

8.0 General Overview, Process Notes

8.1 Introduction

The Mix&Match technology has long been used by the microfabrication facilities to utilize their lithography equipment more efficiently. This is specially important in the dynamic world of semiconductor industry, where device sizes are on a shrinking path and the need for more advanced lithography equipment with better resolution capability are an inherent part of the operation. By moving the critical layers onto more advanced equipment and extending the life of existing older equipment for non-critical layers, the cost of operation can be effectively reduced. There are essentially two paths available for mix and matching layers on exposure tools, based on machine compatibility and the alignment schemes used by such tools. The first method involves mix and matching of lithography layers on the same brand of exposure tools, which most likely use similar alignment schemes, i.e. ASML 2500, 5000 series or 5500 series. This is a much more straightforward task than a second method, which could involve different brands or generation of tools. This report focuses on the latter, involving the Microlab ASML 5500/90 and GCA8500 model steppers. These steppers use different alignment schemes, also print different maximum field sizes. This means that the grid size and placement, the wafer to chuck positioning procedure, as well as the type of target used for the alignment scheme are all different; all of which make the Mix&Match scheme more challenging.

8.2 Experimental Procedure

The Mix&Match procedure in the Microlab was developed primarily by printing two consecutive layers from the CMOS Baseline 170 design layout on the ASML and GCAWS6 steppers. Overlay performance (layer to layer registration) was evaluated between the contact layer, printed on the ASML, and the next layer, Metal1 on the GCAWS6 stepper. The contact layer was printed and etched into a thin oxide film, followed by Metal1 printed and etched into a thin poly layer on top of the oxide. This provided sharper images for SEM inspection and overlay measurements. Test wafers were split at the Metal1 lithography step, where one group of wafers received global alignment only, while the other group was processed with global alignment and µ-DFAS alignment on the GCASW6 stepper (Figure 1), as in the following steps:

1. Printed and etched PM marks as the zero layer on the ASML stepper, etched in lam5.
2. Exposed the first layer (contact) on the ASML stepper by aligning contact to PM marks (zero layer). Global alignment and µ-DFAS targets were also printed as part of the die in specific locations, following the GCAWS6 mask design specifications. This was needed for GCAWS6 alignment (Global + µ-DFAS) at the Metal1 lithography step.
3. Etched the contacts into the oxide layer on all wafers with the Centura MxP+.
4. A thin layer of poly was then deposited on all wafers.
5. The wafers were split into two groups to evaluate global and global+µ-DFAS alignment schemes on the GCAWS6 stepper.
6. Metal1 resist pattern was then transferred into the poly film by etching the samples in the Lam5 etcher.

Note: Once the PM marks and the global+µ-DFAS targets are etched into the substrate, all subsequent ASML and GCAWS6 layers could be aligned following the standard steppers procedure. The ASML layers would use the PM marks and GCA layers align to the global and µ-DFAS targets.

8.3 Unexpected Difficulties

There is a mechanical stage difference between the ASML and the GCAWS6 steppers, which manifests itself as gross rotational and X-Y translational offset (mm range) on printed layers. It was required to find a viable method to compensate for this effect by first applying a wafer rotation (θ) at the ASML layer, then X and Y translational offset in the GCAWS6 job to bring the global targets within the GCAWS6's capturing range with the joysticks. This basically forced the ASML exposure grid to match the GCAWS6's grid, as no wafer rotation feature is available on the GCAWS6 stepper. We experimented with the ASML wafer rotation in the range of + 2° to - 2°, which later resulted in the best choice of θ = - 0.5°.

8.4 Results

The overlay results of the Mix&Match process was, in some cases, better than the vendor specification in the X and especially in Y directions as long as the μ-DFAS targets were used for GCA alignment. Registration accuracy was limited by the performance capability of the GCA stepper for the Mix& Match process. Other factors, such as operator skill (how well global targets were aligned on the GCA stepper screen), stepper calibration could also play a role in the overlay registration quality. To minimize such effects, we performed a μ-DFAS baseline correction before exposing our Metal 1 layer.

Specific Mix&Match jobs on both the **ASML (wafer rotation of θ = - 0.5°)** and **GCAWS6 (target key offset of X = 1.019 mm and Y = 0.5418 mm)** were implemented, which brought the global targets within the capturing range of the GCAWS6 stepper, and made the Metal1 layer exposure possible.

Vendor specification for the lithography equipment:

ASML overlay accuracy:	< 70 nm
GCAWS6 overlay accuracy:	< 150 nm for μ-DFAS targets
	< 350 nm for global targets only

8.5 CAD Design

New GDS templates are made available on Silicon2, available to all users on the following location: **/home/mercury4/cad/mix_match**

ASML_Mix_Match-1field_anylayer.gds
ASML_Mix_Match-1field_zerolayer.gds
ASML_Mix_Match-4field_anylayer.gds
ASML_Mix_Match-4field_zerolayer.gds
ASML_Mix_Match-MaxField_anylayer.gds
ASML_Mix_Match-MaxField_zerolayer.gds

9.0 <u>Equipment Operation</u>

N/A

10.0 <u>Troubleshooting Guidelines</u>

N/A

11.0 Figures & Schematics

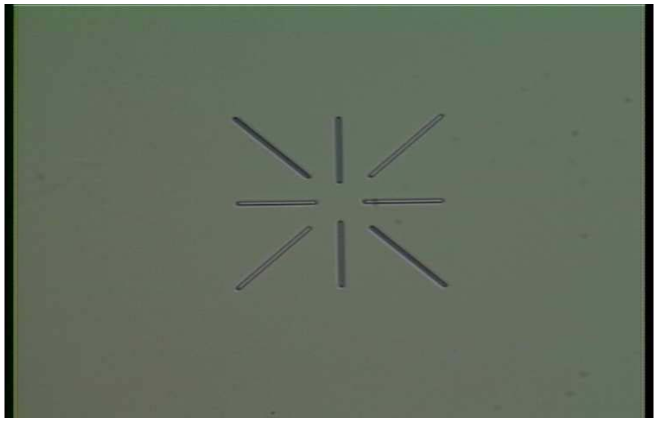
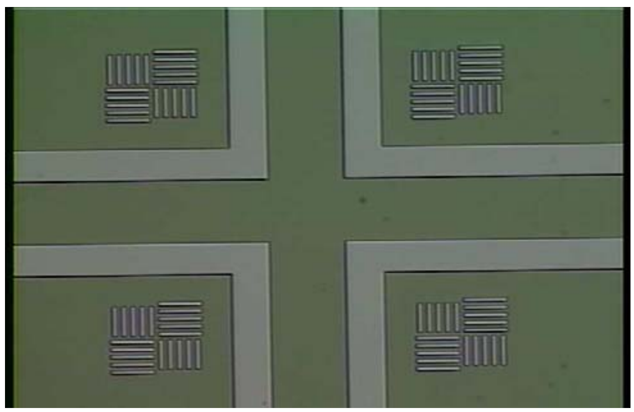


Figure 1 - Images of GCAWS6 Global Target (above) and μ-DFAS Targets (below)



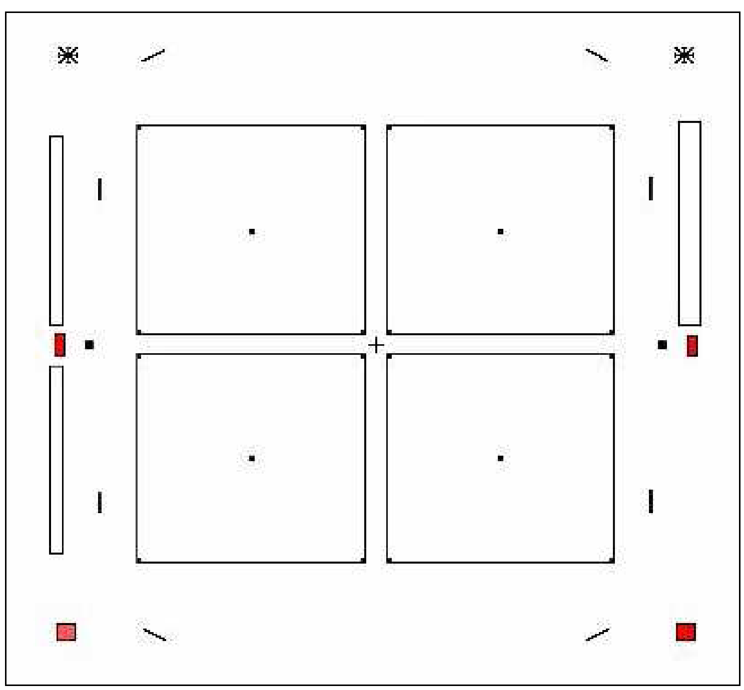


Figure 2 - Four field Version of the ASML Mix&Match Template

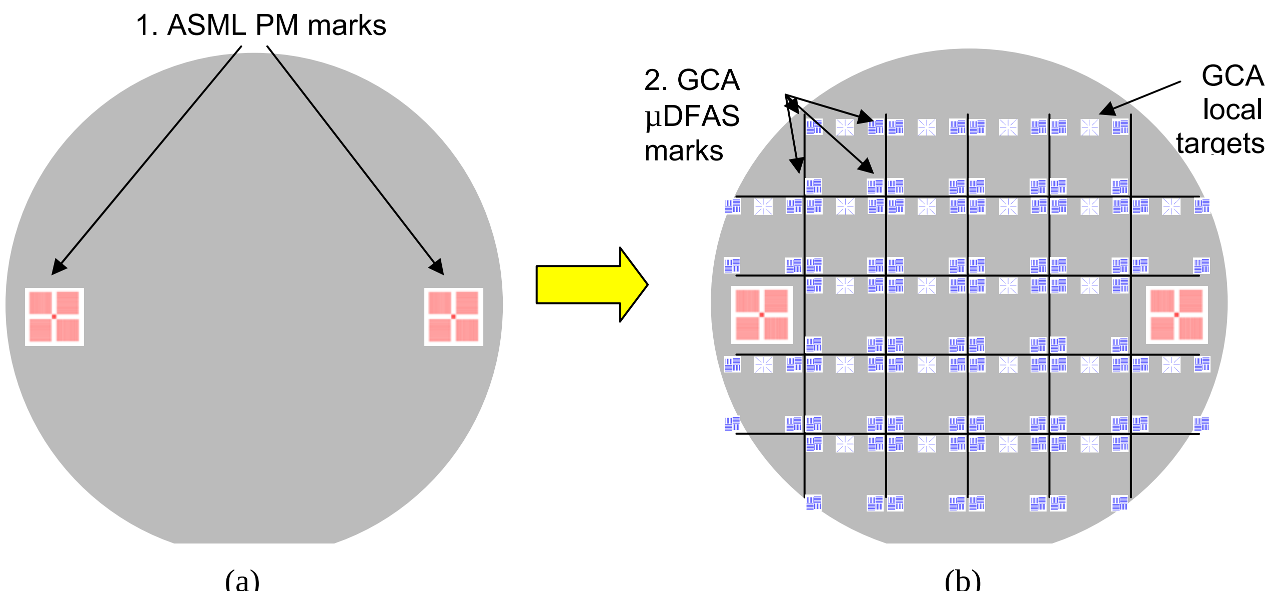


Figure 3 - ASML PM Marks and GCA Global Alignment/µDFAS Targets

12.0 Appendix

12.1 Mix&Match process in CMOS Baseline 180

The Mix&Match process incorporated both DUV and I-line lithography, where 11 out of 22 total layers were exposed on the GCA stepper, and the rest on the ASML. The alignment compatibility was established by matching the ASML grid to that of the GCA and by applying a - 0.5^{o} rotation. A second mask (COMBI2) defines the die grid and the GCA alignment marks, with respect to the ASML PM alignment marks. This is done at the first lithography step in the process by the following steps.

1. The Zero layer exposed on the ASML stepper defined the PM marks at - 0.5^{o} wafer rotation.
2. The ASML PM marks were then etched (Figure 3) into the substrate for consequent ASML layer alignment and for printing the Mix&Match zero layer.
3. The Mix&Match zero layer was aligned to the above ASML PM marks. This layer defined the Mix&Match die grid used by both the GCA and ASML steppers and printed the necessary GCA global and µDFAS (local) alignment targets. These targets printed in every die were used for local alignment by consequent GCA layers. This mask also included some auxiliary structures that made the job of manually locating global alignment targets easier for the GCA stepper layers.

   Note: The baseline die size was changed to 10.16 mm x 10.16 mm to accommodate the fixed distance between the two objective lenses of the GCA alignment camera.

   - Target coordinates defined by right key offset: (- 0.1129, 4.6982)
   - Dropout dies (2,6) (2,9) (7,2) (7,12) (14,6) (14,9)

4. The Mix&Match Zero layer is then etched into substrate (including the global alignment and µDFAS targets).

Step Nr.	Process Step	Substeps	Equipment / Recipe	Target and Process Specification	Notes
1	**INITIAL OXIDATION**	a) TLC clean	Tystar2, 2TLCA	2 hours of cleaning	
		b) Standard cleaning	Sink 6	Piranha + 25:1 HF until dewets	
		c) Dry oxidation	Tystar2, 2DRYOXA	Target: 250 A 950ºC, 30 min; 20 min N2 annealing	
2	**ZERO LAYER PHOTO**		ASML	COMBI mask UVBAKE pr. J	Defines ASML alignment PM marks
3	**SCRIBE WAFERS**		Diamond pen	Scribe numbers into the photoresist	
4	**ZERO LAYER ETCH**	a) Etch through oxide	Centura-MxP+, recipe: MXP_OXSP_ETCH	250 A etch	
		b) Etch PM marks	Lam5, recipe: 5003	1200 A etch	
		c) Photoresist strip	Matrix	2.5 min O2 ash	
		d) Measure etch depth	ASIQ		
		d) Standard cleaning	Sink8		
5	**MIX&MATCH ZERO LAYER PHOTO**		ASML	COMBI2 mask UVBAKE pr. J	Defines GCA alignment marks
6	**MIX&MATCH ZERO LAYER ETCH**	a) Etch through oxide	Centura-MxP+, recipe: MXP_OXSP_ETCH	250 A etch	
		b) Etch PM marks	Lam5 recipe: 5003	1200 A etch	
		c) Photoresist strip	Matrix	2.5 min O2 ash	
		d) Measure etch depth	ASIQ		

Table 1 - Process steps for PM Marks and GCAWS6 Alignment Marks from the CMOS Baseline 180 Process Flow