

From: Marilyn Kushner

To: Sia Parsa

cc: Bill flounders, Bob Hamilton and the Process Group

Date: July 17th, 2013

Subject: OCG 934 3:2 developer evaluation a replacement for OCG 934 2:1 developer.

Introduction:

In May 2013 we were notified that the FujiFilm 934 2:1 developer (our current developer) was going to get discontinued. The OCG 934 2:1 has been used to develop our G-line resist (OCG 825 35CS) for many years. We immediately contacted FUJIFILM Electronic Materials for advice. A functional replacement was recommended at a higher concentration (higher normality) than the current developer marketed as 934 3:2 G-line developer. The new developer had a normality of 0.132n somewhat higher than our current 934 2:1 developer with a normality of 0.110n. This meant the new developer was not a "plug & play" replacement, therefore some work needed to get done up front to implement it in the NanoLab. This included dialing the exposure energy and develop time to match performance of the current (discontinued) developer, as per follows.

Experimental Procedure:

*Note: for all test phases, the wafers were post-exposure baked for 60 seconds@120 deg. C.

Phase1 - Clear Energy Test (Blank Mask)

Two bare silicon wafers were coated with OCG 825 35CS G-line resist.

Clear energy test (E_0) - Exposure Energy Test was performed on these two wafers with an open frame (blank mask) at aperture setting of 37.5 in both X and Y. The samples were then split, one received dish developed in OCG 934 3:2 Developer (new) for 60 Seconds. The other wafer dish developed in OCG 934 2:1 (current developer) for 60 seconds. As expected the new developer was much faster, hence required less energy to clear the open frame exposure fields.

OCG 934 2:1 Developer clear energy = 0.36 sec.

OCG 934 3:2 Developer clear energy = 0.23 sec.

Phase2 - FEM test (Pattered Dark Field Mask)

Four bare silicon wafers were coated with OCG 825 35CS G-line resist to determine the best exposure and focus required to resolve minimum features sizes.

FEM for best focus and exposure energy (dot matrix and rosette structures) - 2 wafers scribed as 2:1 group and the other 2 wafers scribed as 3:2 group. FEM (focus exposure matrix) with

apertures setting of 37.5 in both X and Y was used to expose a dark field mask. These wafers were dish- developed at msink1 for 60 seconds.

OCG 934 2:1 best focus/exposure: Focus =-12 Exposure : 0.46 sec.

OCG 934 3:2 best focus/exposure: Focus = -6 Exposure: 0.36 sec.

The dark field pattern in these cases did not produce good conclusive images for this comparison study, therefore decision was made to repeat the test with a clear field mask and track develop was used for a better develop process and image quality.

Phase3 - FEM test (Pattered Clear Field Mask)

Svgdev2 reserved for the day and David Lo switched over the developer line to a new canister filled with the OCG 934 3:2 developer to run our test with the new developer. The developer line was thoroughly purged for this purpose by running 20 blank dummy wafers through the system to clear out the old developer (934 2:1) from the line and nozzle. Exposed FEM for this group of wafers were then track developed. The old developer was then changed back to continue with the other group (FEM) for our comparison study. There were initially some issues with the SEM cross section charging up the resist pattern as well as resist damage that occurred on the new developer group developed at standard 60 seconds develop time. The decision was made to try Olympus Microscope, also ease back on the develop time for the case of the new developer. 1.0 um line/space measurements and resist profiles were assessed (see images at end of report) to determine the best development time, focus, and exposure time. Findings in Phase 3 are summarized as follows:

OCG 934 2:1 best focus/exposure: Develop time = 60 sec. Focus =24 Exposure : 0.54 sec.

OCG 934 3:2 best focus/exposure: Develop time = 45 sec. Focus = 6 Exposure: 0.46 sec.

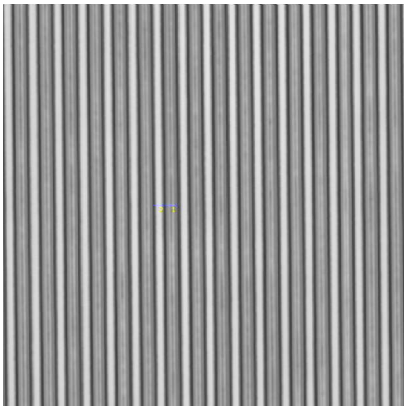
The conditions determined for the OCG 934 3:2 developer (above in bold) is the recommended starting point for photolithography in the Nanolab. These reported conditions are optimized for 1 um lines and spaces. It is important to note that larger geometries will require less exposure time to prevent over exposure.

Results and Conclusion

The new developer produced comparable results at a lower develop and energy pointing out the nature of the high normality developers which is often desired by G-line process users in the lab. The new developer will require around 15% less energy and 20% less develop time to produce the same images attained by our current developer. This feature may also come useful in the lift off process (bi-layer method).

New 934 3:2 DEVELOPER RESULTS

934 3:2 Developer, Dev. Time = 45 sec
Focus = 6, Exposure = 0.46

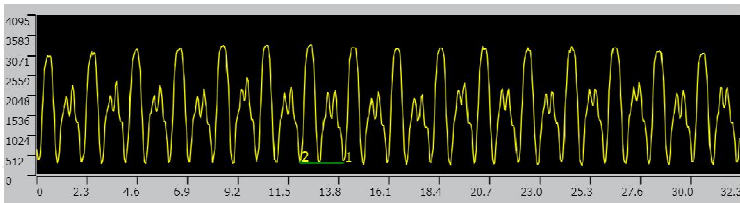


User ID: NANOLAB
User name: Nanolab
Description:

046 834 3to2 45sec
[Acquisition parameters]
Scanning mode: XYZ fine scan
Image size[pixels]: 1024X1024
Image size[μm]: 32x32
Objective lens: MPLAPONLEXT100x
Zoom: 4x
DIC: Off

Comment

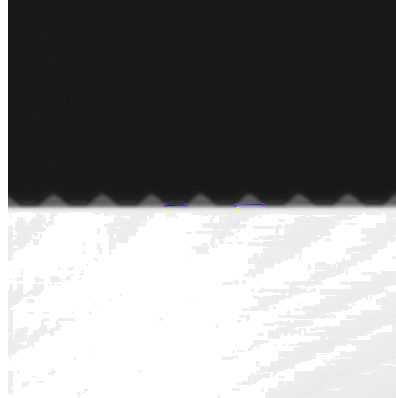
No.	Result	Width[μm]	File name
<input checked="" type="checkbox"/> 1		1.071	Overview_07
<input checked="" type="checkbox"/> 2		0.945	Overview_07
Count		2	2
Average		1.008	
Min.		0.945	
Max.		1.071	
Range		0.126	
σ		0.089	
3σ		0.267	
Tolerance		Off	Off
Upper tolerance		0	
Standard		0	
Lower tolerance		0	



1/1

6/28/2013

934 3:2 Developer, Dev. Time = 45 sec
Focus = 6, Exposure = 0.46



User ID: NANOLAB
User name: Nanolab
Description:

Overview_069
[Acquisition parameters]
Scanning mode: XYZ fine scan
Image size[pixels]: 1024X1024
Image size[μm]: 16x16
Objective lens: MPLAPONLEXT100x
Zoom: 8x
DIC: Off

Comment

No.	Result	Distance[μm]	File name
<input checked="" type="checkbox"/> 1		0.819	Overview_069
<input checked="" type="checkbox"/> 2		1.113	Overview_069
Count		2	2
Average		0.966	
Min.		0.819	
Max.		1.113	
Range		0.294	
σ		0.208	
3σ		0.624	
Tolerance		Off	Off
Upper tolerance		0	
Standard		0	
Lower tolerance		0	

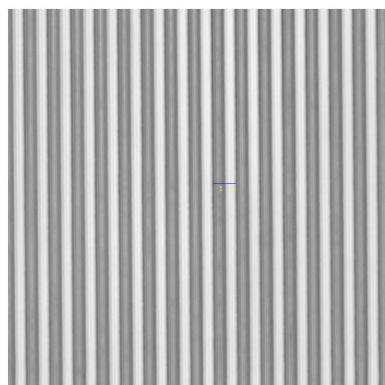
1/1

6/28/2013

PREVIOUS 934 2:1 DEVELOPER RESULTS

LEXT

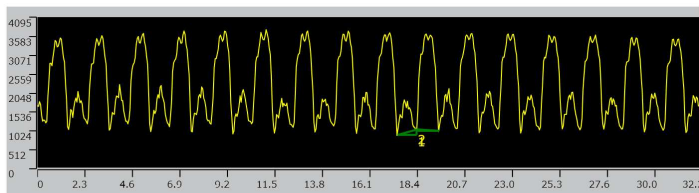
**934 2:1 Developer, Dev. Time = 60 sec
Focus = 24, Exposure = 0.54**



121812 Chan 6 Map_060
[Acquisition parameters]
Scanning mode: XYZ fine scan + Color
Image size[pixels]: 1024X1024
Image size[μm]: 32x32
Objective lens: MPLAPONLEXT100x
Zoom: 4x
DIC: Off

line = 0.913 μm
space = 1.102 μm

No.	Result	Width[μm]	File name
<input checked="" type="checkbox"/>	1	0.913	121812 Chan
<input checked="" type="checkbox"/>	2	1.102	121812 Chan

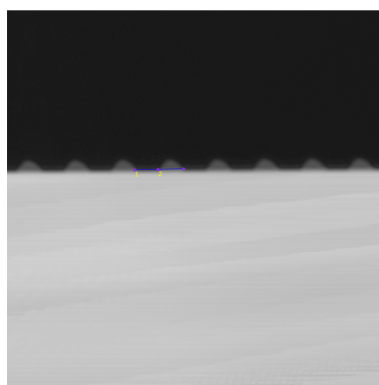


1/1

7/5/2013

LEXT

**934 2:1 Developer, Dev. Time = 60 sec
Focus = 24, Exposure = 0.54**



121812 Chan 6 Map_063
[Acquisition parameters]
Scanning mode: XYZ fine scan
Image size[pixels]: 1024X1024
Image size[μm]: 16x16
Objective lens: MPLAPONLEXT100x
Zoom: 8x
DIC: Off

Comment

No.	Result	Distance[μm]	File name
<input checked="" type="checkbox"/>	1	1.008	121812 Chan
<input checked="" type="checkbox"/>	2	1.092	121812 Chan

1/1

7/5/2013

Acknowledgement

I would like to thank the Process team specifically Kim and Jeff for their SEM and confocal microscope work, as well as guidance and support.