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Analyzing the role of developer compositions on resulted images in Positive and Negative tone photoresist

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Abstract

The photoresist developers, for both categories MIF and MIB were prepared and tested for image developing of positive and negative tone photoresists.

The best results from roughness and sidewall angle point of view were found to be resulted from aqueous solutions. Optical microscope images in different magnifications studies endorse the differences in quality of gained images. The aqueous developer which is the first Iranian developer showed a great capability to achieve acceptable results down to submicronic patterns.

Keywords: Photoresist developer, MIF, MIB, Positive and negative tone.

Introduction

Positive tone (DNQ based) photoresists are the most common type of liquid photoresists which have been used for decades all around the word. On the other hand negative tone photoresists are new, more accurate and so harder to develop. Developing is one of the most crucial stages in photolithography as it can totally affect the resulted images but it remained unnoticed during the last years in lots of new laboratories and research centers.

There are numbers of developers in use for DNQ/novalak resists. The most important two classes are the buffered metal-ion containing (MIB) and the metal-ion free (MIF) developers. Because lack of access, shipping problems and their unaffordable cost in some cases, commercial developers are substituted by self-made solutions in some cases but obviously they can never achieve desired resolution.

In this paper, we report the performance of the above mentioned solutions for developing negative tone KMPR 1005 and positive one Shipley 1813 photoresists. These two photoresists are chosen since they are commercial and worldwide famous samples.

Experimental method

Six silicon wafers were prepared as follows: Firstly they went through conventional technical surface preparation steps RCA-1 and RCA-2. It helps to remove organic or metallic residues from surface. Then each wafer was covered by an appropriate amount of a type of photoresist which was spin coated due to its datasheet information. After soft bake process they were exposed by a contact printing UV-exposer device using a chromium mask.

The next step is developing the exposed photoresists which was done using different types of developers represented in "Table 1".

Development and DI water rinsing are the last steps before microscope inspection. Developing stage contains gentle agitation of immersed wafer in developer solution all during the mentioned period of this stage. The samples for Optical inspection were prepared by dividing wafers, which were imaged as said before, into pieces to place under device. Preparation procedure is stated in brief in "Table 1" below.

N.O	Photo Resist	Soft bake	Developer	Develop Time
1.1	KMPR 1005	100°c 5 min	Commercial	2-3 min
1.2	Shipley 1813	115°c 1min	Commercial	2-3 min
2.1	KMPR 1005	100°c 5 min	AUT-MEMS	2-3 min
2.2	Shipley 1813	115°c 1min	AUT-MEMS	2-3 min
3.1	KMPR 1005	100°c 5 min	KOH	2-3 min
3.2	Shipley 1813	115°c 1min	KOH	2-3 min

Table 1: Wafers preparation procedure

Results and Discussion

"Fig1" shows a line which was developed by MIB developer. Not satisfactory side walls and rough surface is disadvantages of such an image. The side wall angle in this case is about 60 degree which is far away from needed and desired angle.

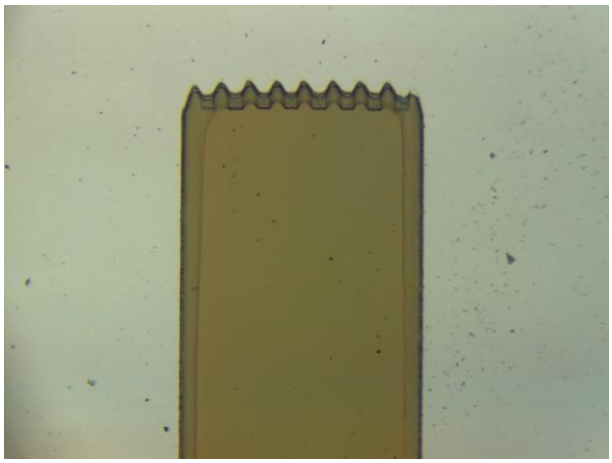

Fig 1: Shipley 1813 developed by MIB developer

These two major problems resulted by metal ion containing developers caused a revolutionary change in this industry. As “Fig 2” shows a complicated design which is well developed with more acceptable side wall angle and resolution.

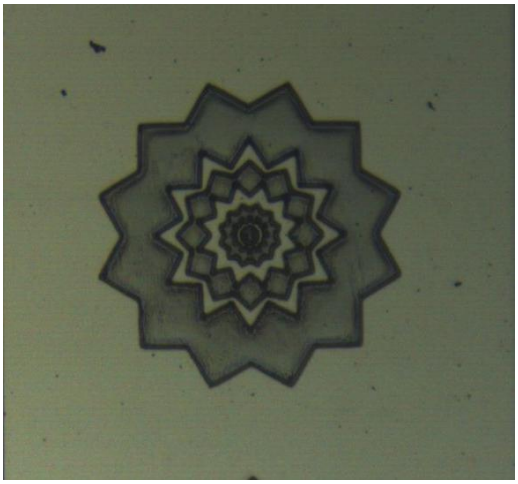

Fig 2: KMPR 1005 developed by AUT developer

In this case the smallest features are about 1 micron and the resolution which seems really good is proved to be totally reproducible and achievable by i-line contact UV exposure.
“Fig 3” shows a negative tone KMPR 1005 Photoresist which is developed by a commercial developer.

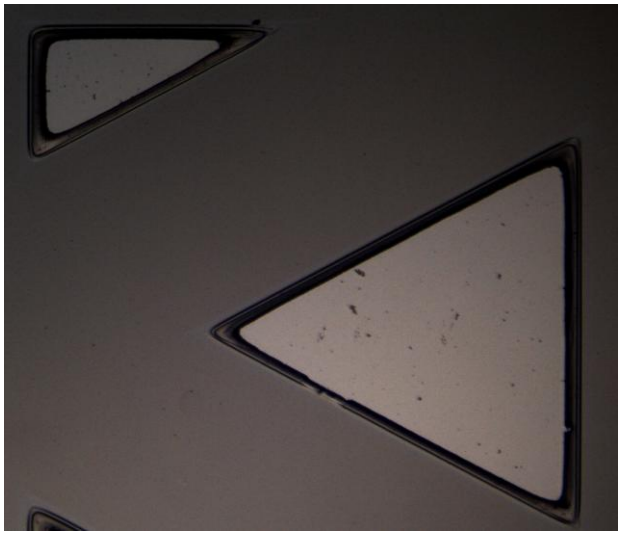

Fig 3: KMPR sample developed by commercial solution

In this case the side wall angle is about 65 degree and the resolution is
obviously unacceptable. The problems are probably caused by bad keeping situations or other affecting items caused by shipping or packaging matters which all could be prevented by using other developers produced in their own country.

It is noteworthy that it may be possible to achieve a better result but the dominating factor is the wider working range of AUT developer in comparison with others.

Conclusions

The coated silicon wafers have been prepared and exposed by UV-light by a contact printer device and then developed by three developers. Resulted images from optical microscope shows a great difference in MIF and MIB developers. Surface roughness is much better in MIF developers. Furthermore, the TMAH based solution gave about 20%better side wall angles and cleaner surfaces on wafer.

Acknowledgment

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References

[1] Wayne M. Moreau, Semiconductor Lithography Principles, Practices, and Materials;, General Technology Divisio, International Business Machines Corporation,Hopewell Junction, New York
[2] Material Safety Data Sheet MICROPOSIT S1813 PHOTO RESIST 41280 4.00 US US 11.06.1998 MSDS_US;Shipley Company.
[3] Ralph Dammel, 1993, Diazonaphtoquinone-based Resists,SPIE.
[4] Material Safety Data Sheet,KMPR Series Resists MicroChem Corp.