RESIST TRANSFORMATION UNDER LOW-K DIELECTRIC PLASMA PATTERNING PROCESSES: IMPACT ON THE PROCESS CONTROL.

E.Pargon, N. Possémé , L. Vallier, O. Joubert,

Laboratoire des Technologies de la Microélectronique (LTM/CNRS)
17 avenue des martyrs (CEA-LETI),
38054 Grenoble Cedex 09, France

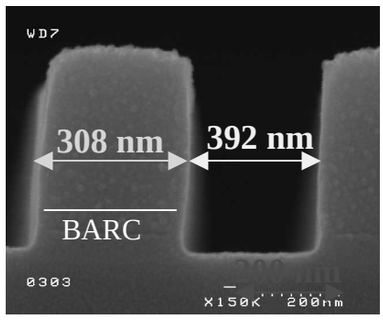
We are now entering an era where a very accurate control and understanding of plasma processes is required to ensure the appropriate scaling of sub 0.1 µm CMOS devices. All the processes involved in microelectronics for the front-end or back-end technologies use photoresist as a mask at least for the first steps of any front end and back end patterning processes. For instance, in the low-k dielectric etching processes, the resist is used during the BARC opening process as well as during the hard mask opening process (SiC or SiO_2 being used as a hard mask). An accurate control of these first steps is critical to ensure the control of final contact and via dimensions. However, resist can undergo some drastic modifications during plasma exposure, which can have an impact on the process control. It therefore becomes of primary importance to understand the photoresist modifications during plasma exposure and to correlate them with the process performance. This study is dedicated to the determination of the resist transformations during the first steps of the low K dielectric plasma patterning processes and the impact they have on the final dimension of trenches or contact holes.

To carry out our experiment, we process the wafers in a MERIE (Magnetically Enhanced Reactive Ion Etcher) and we characterize the resist modifications during plasma exposure thanks to a new methodology derived from in-situ XPS analyses. The XPS acquisitions enable us to determine the chemical composition as well as the thickness of the reactive layers formed both on top and sidewalls of the resist patterns after plasma exposure. The process performance (vertical and lateral etch rates) are determined thanks to high resolution SEM observations after process.

We have focused our studies on the correlation between the capability of a fluorocarbon gas to generate polymers during a BARC or hard mask opening process and the resist transformations.
For instance, in a BARC opening process, the photoresist transformation can be completely different according to the plasma chemistry used. Using CF4 as a BARC opening chemistry leads to the deposition of thick reactive layers on the resist sidewalls generating an increase of the initial critical dimension, whereas when using a O_2/N_2 chemistry, the formation of a thin reactive layer on the resist sidewalls generates some resist trimming which in final induces a decrease of the critical dimension targeted. Figure 1 shows the two different etching profiles of the photoresist after a BARC opening process using a CF_4 or O_2/N_2 chemistry.
We have also studied the hard mask opening process using either a SiO_2 or a SiC hard mask. These materials are often etched with fluorocarbon chemistries and our study reveals that these chemistries can have a real impact on the final dimensions of trenches due to the formation of thick fluorocarbon layers on the resist sidewalls.

Thanks to this XPS methodology, we can accurately correlate the resist transformations occurring on the resist sidewalls with the process performance. In final, we will demonstrate that the critical dimension of trenches and vias patterned in Low k materials can be controlled by adjusting a balance between deposition and etching of the fluorocarbon layer formed on the resist sidewalls and directly driving the final resist dimension.

(a)



(b)

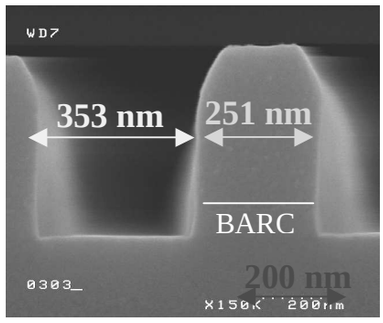


Figure 1: Etching profile of the photoresist after a BARC opening process: (a) CF_4 chemistry, (b) O_2/N_2 chemistry. Same initial lithography (Line=300nm; Space=300 nm)