Real time scatterometry for 193 nm photoresist trimming monitoring: influence of the refractive index modification on CD accuracy

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Nowadays, the scatterometry, an optical-based metrology technique, plays an important role in the semiconductor industry for dimensional control of submicron features. Dimensions of the considered grating structure can be determined thanks to an analysis of the light diffracted by this grating. This technique started finding numerous industrial applications [1]. Our group develops the scatterometry technique for *in situ* detailed topography extractions in real time mode. The aim is to monitor the profile shape evolution of the structure during different steps in semiconductor manufacturing processes, such as resist trimming process. The extraction of the parameters defining the structure geometry from the experimental data is real time compatible thanks to the library method and specific software tools running on Graphics Processor Units (GPU)[2].

The feasibility of the 248nm photoresist trimming process control has been demonstrated [3, 4]. 248nm photoresist is now replaced by 193nm photoresist. This allows reaching the resolution requirements of current generation device dimensions in the semiconductor manufacturing. This leads to new challenges caused by the photoresist transformation [5] during the resist trimming process. One of the major concerns for scatterometry is the refractive index modification occurring during the plasma exposure.

In this article, experimental results of *in situ* and real time scatterometry control of 193 nm resist trimming processes for 250nm dense lines pattern structure are shown. The dynamis aspects of the results are illustrated in a movie format. As far as we know, these results are the first demonstration of real time scatterometry to control an etching process of a 193nm resist. The optical setup is installed *in situ* on one of the chambers of a “DPS CENTURA from APPLIED MATERIALS”. These results lead to a better understanding of the optical modifications of the JSR1682 193nm photoresist induced by the etching process. These modifications can then be integrated into the scatterometry model in order to improve the accuracy of the critical dimension control. The limitations provided by the ellipsometer tool are also discussed. The chemical modifications induced by the plasma conditions through the measurement of the optical index are presented (Fig. 1, 2). Finally, we explain how this issue can be addressed in the *in situ* and real time control of the resist trimming processes by the scatterometry tool.

In order to validate our results, experimental measurements are compared to 3D AFM considered here as a reference technique.Figure. 3 depict the CD evolution extracted using real time scatterometry compared with AFM measurements. It shows a good agreement with a difference less than 2%.

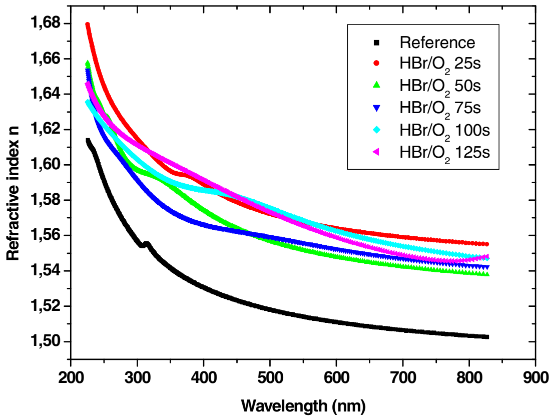

Figure1: Evolution of refractive index n of the JSR1682 with the plasma treatment processing times

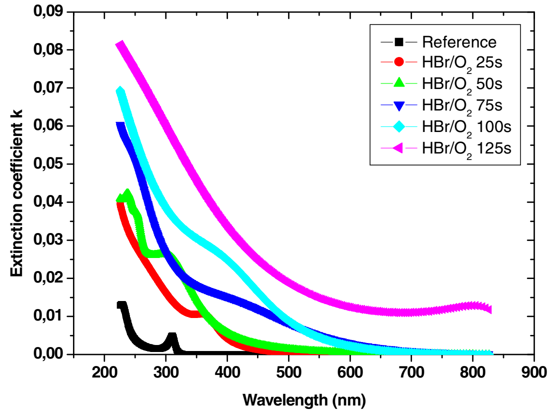

Figure 2 Evolution of extinction coefficient k of the JSR1682 with the plasma treatment processing times

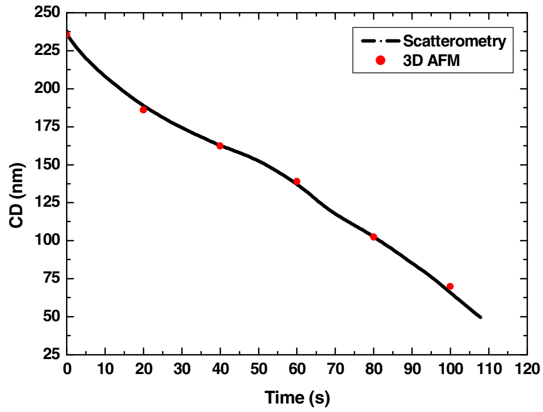

Figure 3: Real time measurement results of CD of the resist feature over the processing time in HBr/O_2 plasma. 3D-AFM data are shown for reference

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