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Line Width Roughness and Critical Dimension Uniformity Improvement in Self-Aligned Contact patterning in DRAM

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ABSTRACT

In advanced DRAM manufacturing, the feature CD size is continuously decreasing and one of the main challenges for Self-Aligned Contact (SAC) patterning is the control of Line Width Roughness (LWR). The smaller the feature CD, the higher the aspect ratio, and the greater the challenge of LWR control. LWR can be subdivided into high frequency and low frequency parts. In this paper, the low frequency LWR caused by higher stress of the mask will be discussed.

Keywords — Line Width Roughness, Critical Dimension Uniformity, Self-Aligned Contact

INTRODUCTION

In LWR, clearly the roughness could represent a considerable fraction of the CD budget. The variation would deteriorate the performance of the device, and guarantee that the device performance had a larger than acceptable variation. This problem scales inversely with the CD, meaning that it is bound to get worse with smaller devices. Self-Aligned Contact patterning demands higher selectivity to the carbon, and this is where the polymerizing chemistry comes in. More polymerizing chemistries are used for dielectric etch and polymer deposition can make roughness worse. It was observed that the LWR was highly correlated to the consumption of the hard mark. With Lam Research Flex® dielectric etch systems equipped with tunable electrostatic chucks (ESC), we demonstrated the capability to improve the line width roughness through the control of polymer recombination during the etch process.

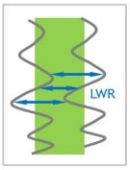
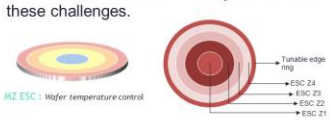


Figure 1. LWR schematic

Meanwhile, we introduce an advanced pulsing function as developed for Lam's Flex® dielectric etch tool family to overcome these challenges.



RESULTS & DISCUSSION

During the etch there is a buildup of polymers either from the carbon fluoride feed gases, or from re-deposition, or both. Strong ion bombardment can cause uneven erosion of the polymers on the sidewall, and the resulting high stress striations translate vertically into the substrate. As for better LWR, we tuned multi zone ESC to lower the mask selectivity to lower the stress and gain better global uniformity.

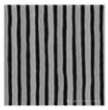


Figure 2. Worse LWR


Figure 3. Worse LWR

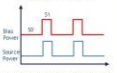


Figure 4. Advanced RF pulsing

Advanced RF pulsing allows better control of ion and radical density to well control of polymer recombination.

SUMMARY

Profile control and dimension uniformity control are equally important in SAC patterning process. In this paper, profile optimization and CD uniformity improvement were also discussed by using advanced RF pulsing together with the tunable temperature option.

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