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STRIATION-FORMATION DURING OXIDE PLASMA-ETCH FOR A 0.35UM TECHNOLOGY

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1 Context / Study motivation

Due to downscaling to the sub-100nm level, the study of striations has become important[1,2]. Striations can be described as roughness along the sidewall of an etched layer using a masking resist layer. Striations are translated into line-width fluctuations that can influence electrical parameters of the planar sub-100nm structure (e.g. fluctuations of the gate length).

In recent literature, most articles are dealing with striations in the sub-100nm node. They explain that the striations are caused by the line-edge roughness (LER) of the resists. D. Goldfarb in [1] explains the translation of LER in the resist to striations in the hard-mask on the basis of AFM-measurements on an etched sidewall; L. Leunnissen in [2] is emulating/simulating the striations using artificial LER; while H. Namatsu in [3] is explaining the LER by entanglement of polymer-chains in the resist.

In this work however, the appearance of striations after plasma-etch is discussed for a 0.35µm technology. In the past the line-width fluctuations caused by these striations were not important for this technology-node, because they were smaller than 10% of the gate-length (or in general the critical dimension) [4]. However, in this work, the gate is not planar, but vertical, since it's used in a trench technology. This means that the striations that are present in the oxide hard-mask will be translated into the vertical gate during silicon trench-etch. Growing a gate-oxide on this "wiggling" silicon-surface can result in reliability issues.

This work investigates the effect of etch-parameters and litho-parameters on these striations for the 0.35µm technology-node.

2 Description of approach / Performed tests

Unlike the sub-100nm technologies, the resist in this work is I-line resist of 1.2µm thick. From literature[2] one knows that the LER is larger for this kind of resist. Apart from investigating the effect of lithography on the striations, this work also looks at the effect of etch-parameters. Since this work deals with a different technology-node (e.g. resist, critical dimension CD, etc.) than what is presented in literature, this appears to be relevant. For this etch-influence, the main focus of this report is on a LAM4526i etcher, although other etchers yielded similar results (AMAT P5000, LAM 4526 XL). The following 2 sections describe the different investigations.

2.1 Influence of Etch-Parameters on Striations

To investigate the influence of the etcher it is opportune to identify the parameters that could have an effect on striations:

- CF4/CHF3-ratio: An increase will result in more aggressiveness, resist erosion and more chance on striations; a decrease in more polymerization, which can reduce the LER and striations[1, 5].
- Argon and bias-power: reducing the aggressiveness will result in less resist-attack and more isotropy[5]. Disadvantage can be loss of CD-control and slope.
- Electrode temperature: bad cooling of the wafer can result in etch-issues and different polymerization.

2.2 Influence of Lithography on Striations

The following litho-parameters are investigated:

- Flash-strip and UV-cure: possibly extra resist treatment could give an improvement on striations.
- Resist: using another resist could improve the striations (better LER, better slope, etc.). Two different I-line resists are tested: OIR620 (FUJIFILM) and IX420 (JSR).
- Focus-offset and exposure dose: Printing out of focus could create more striations. A higher exposure dose could improve the striations (e.g. better slope).

The different experiments are evaluated by binning the SEM-inspection result. The following section discusses the obtained results.

3 Results and Conclusions

From this work one can conclude that following parameters have the largest influence on striations: (a) usage of P5000 vs. LAM4526; (b) increasing the exposure dose and apply positive focus offset; (c) using UV-cure instead of post-baking the resist.

3.1 Influence of etcher (AMAT P5000 vs. LAM4526i)

For this experiment 2 different P5000 were used and compared to LAM4526i and XL. The results show clearly the benefit of the P5000, although emulating these recipes on the LAMs did not gave the same results. In fact all test on LAM appeared to result in striations. Perceived was that the P5000 is more giving an isotropic etch (minor loss of CD), which is known to be advantageous for striations.

3.2 Influence of litho conditions (dose and focus)

A higher exposure dose results in a higher CD. However, it also appears that the slope of the resist becomes better (for positive focus offsets), which is correlated to the striations. The combination of a higher dose and slightly positive focus is needed to reduce these striations. Positive results are seen starting from a dose of 1200J/m² (for JSR IX420).

3.3 Influence of UV-cure replacing the post-bake

The effect of the UV-cure is largely visible on sidewalls neighboring large resist areas, which tend to shrink during post-bake, giving sloped sidewall resulting in striations. Since this outer structure is often part of the active device, this can result in decreased device-performance. When using UV-cure, the resist is fixated, resulting in a similar slope as elsewhere in the device. Best results are obtained at 100degC.

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