Spatial Frequency Analysis of LER and LWR to Tune SADP Process

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ABSTRACT

In the SADP process, the final spacer line roughness is the key challenge for good pattern transfer. To understand how each process step contributes, the role of roughness in different frequency ranges (Low, Middle, High) is extremely important and it was thoroughly analyzed using unbiased power spectral densities. In this way, it was possible to observe that the deposition step introduces Low to Middle frequency LWR. By tweaking the thin film stress levels during deposition, it is observed that LWR of the final CD of the spacer line can be improved further after the etch step. Applying proper etch step tuning, the etch power condition optimization can reduce line wiggling (responsible for Low frequency LER), while gas flow adjustment can minimize residue from re-deposition (and therefore improve Middle frequency LER). Using the insights in frequency range enabled rapid reduction of LER and LWR by focusing the development methods in both deposition and etch.

Keywords: Spatial Frequency Analysis, Roughness

INTRODUCTION

Continued scaling of memory and logic devices poses many challenges that cannot be solved through advanced lithography techniques alone. Multi-patterning techniques have enabled extremely small line widths through SAxP and LEx, but there are still many challenges that limit scaling. The largest variation in a typical SADP process is feature roughness, defined as LER (line edge roughness), LWR (line width roughness), and SWR (space width roughness). Roughness is rapidly becoming the key scaling limiter and addressing this with deposition and etch provides an opportunity for materials-enabled solutions to facilitate device scaling [1].

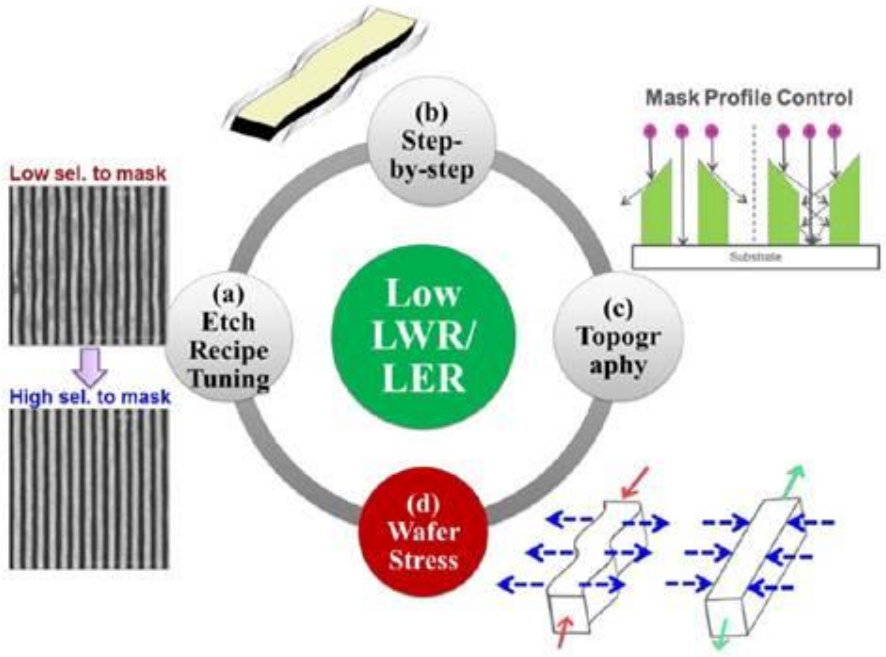

Fig. 1 Potential line roughness performance improvement solutions on SAxP flow [1].

METHODS

In the SADP process, controlling roughness of the final spacer is the key challenge to achieve good pattern transfer. It's therefore critical to understand where roughness originates throughout the process flow. Using unbiased power spectral densities, thorough analysis of different frequency ranges (Low, Middle, High) per process step were quantified [2]. In this way, it was possible to observe that the deposition step introduces Low to Middle frequency LWR.

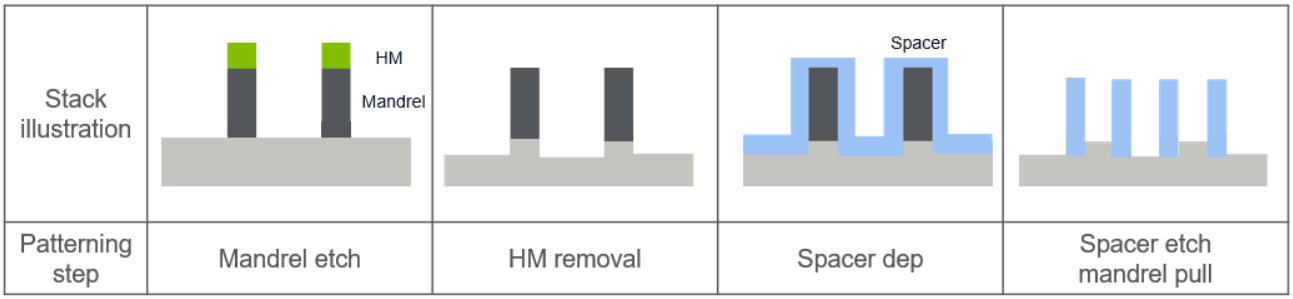

Fig. 2 SADP stack and process flow illustration.

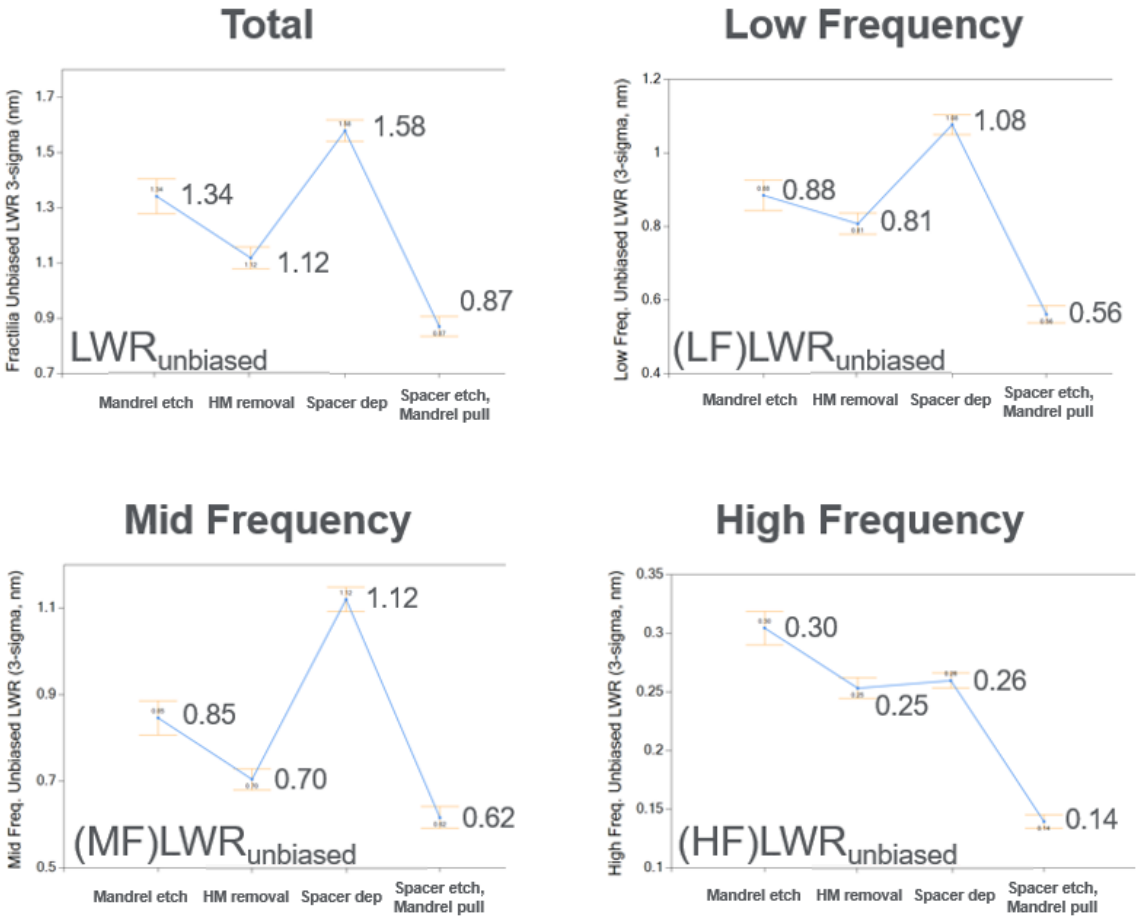

Fig. 3 Deposition step introduces Low to Middle frequency LWR. Length for low frequencies: 50nm. Length for high frequencies: 10nm.

RESULTS

Process co-optimization is key to controlling final CD spacer roughness. Tweaking thin film stress during spacer deposition enables further LWR reduction post etch. Tuning the etch power condition has been shown to reduce line wiggling (responsible for Low frequency LER), while adjusting gas flow can minimize residue by mitigating re-deposition (thus improving Middle frequency LER).

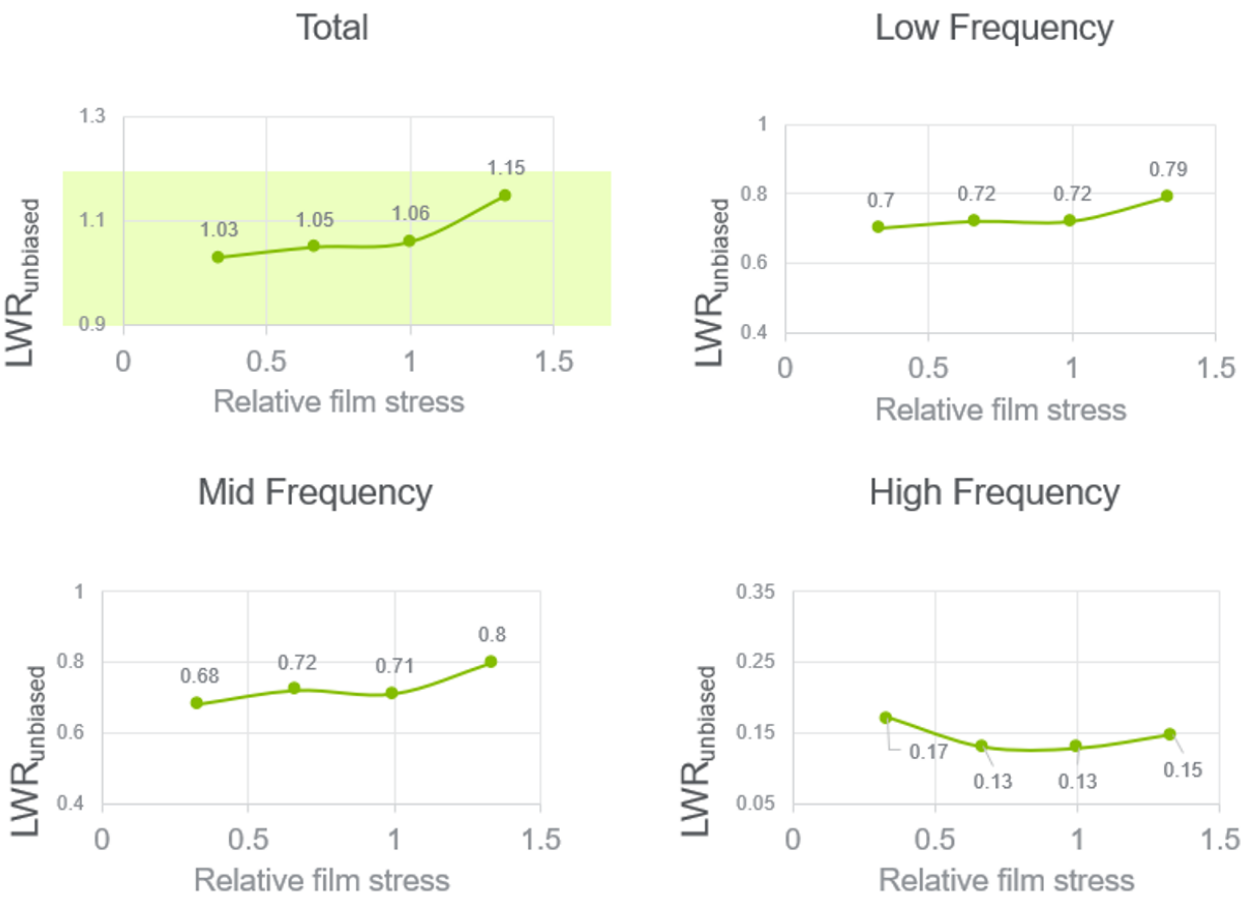

Fig. 4 Lowering thin film stress levels during deposition enables further spacer LWR reduction after the etch step.

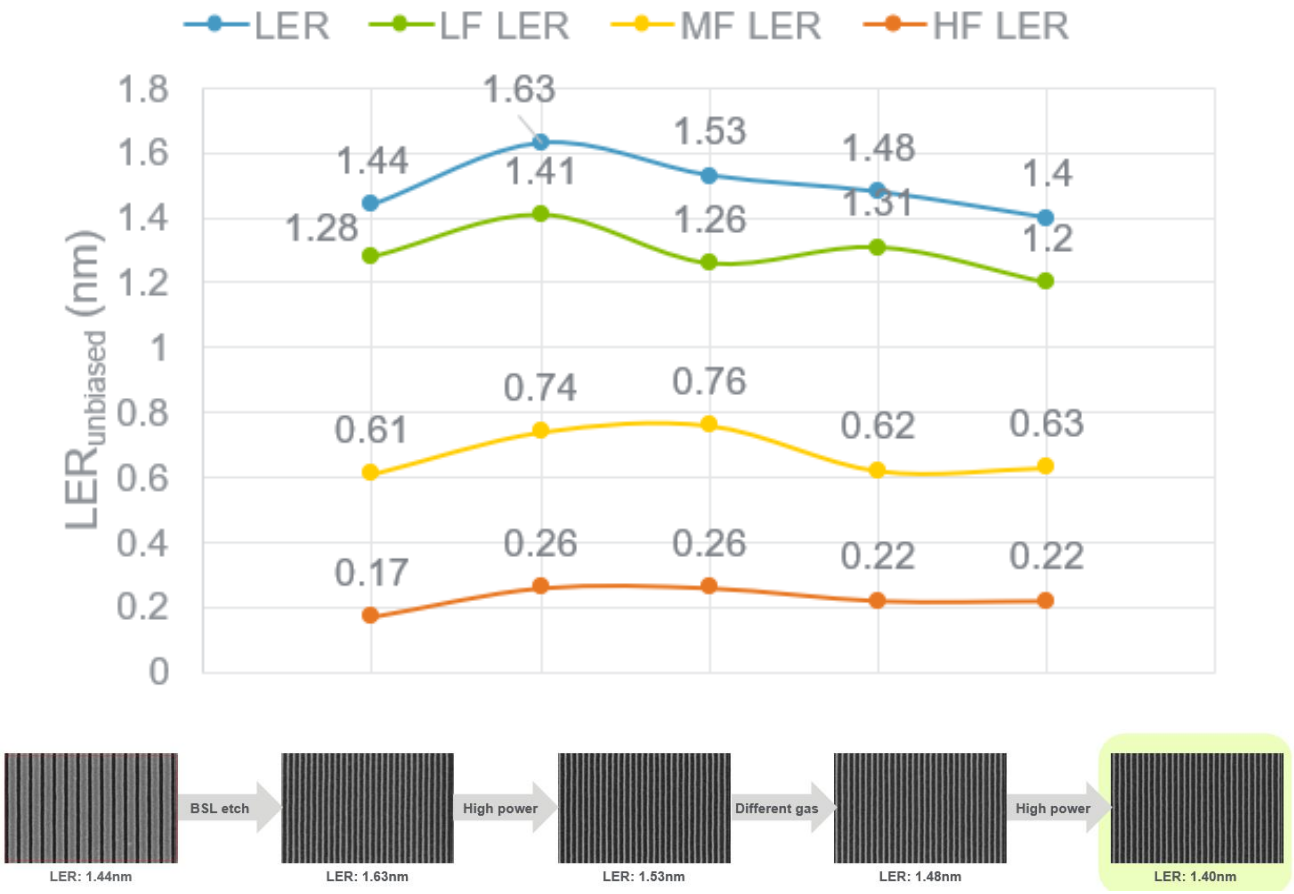

Fig. 5 Low to Middle frequency LER can be minimized through proper etch step tuning.

CONCLUSIONS

Analysis of roughness frequency ranges per SADP process step aids co-optimization of spacer deposition and etch to rapidly reduce LER and LWR.

REFERENCES

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