A Study of Removing Scan Damage on Advanced ArF PSM Mask by Dry Treatment before Cleaning

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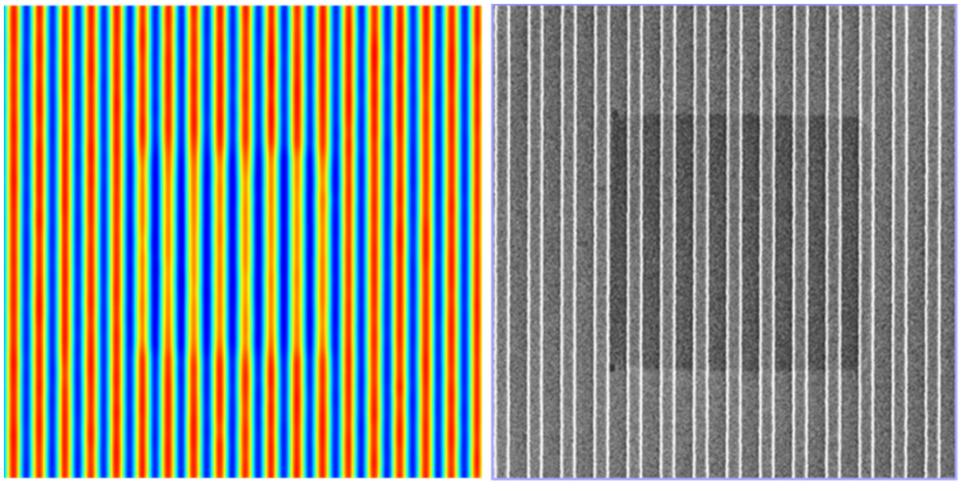
Outline

- Introduction
- Experimental
- Date & Analysis
- Summary & Acknowledgement

Introduction

EB (Electron-beam) repair is widely applied to deal with critical defects on advanced ArF PSM mask, and challenging defects may require several repair cycles. However, the cumulative scanning during repair processes would cause scan damage issues, shown as dark on CDSEM image, and transmission rate abnormal on Aims image.



a. Aims image with scan damage b. CDSEM image with scan damage

Figure 1 Repair Scan Damage Issue

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Experimental

A novel approach using dry treatment based on reactive plasma Asher to deal with scan damage would be introduced. The process is to supply O2 mixed with innocuous H2O, H2 or other gases in the plasma Asher chamber, then gases are ionized into plasma and strike the mask surface.

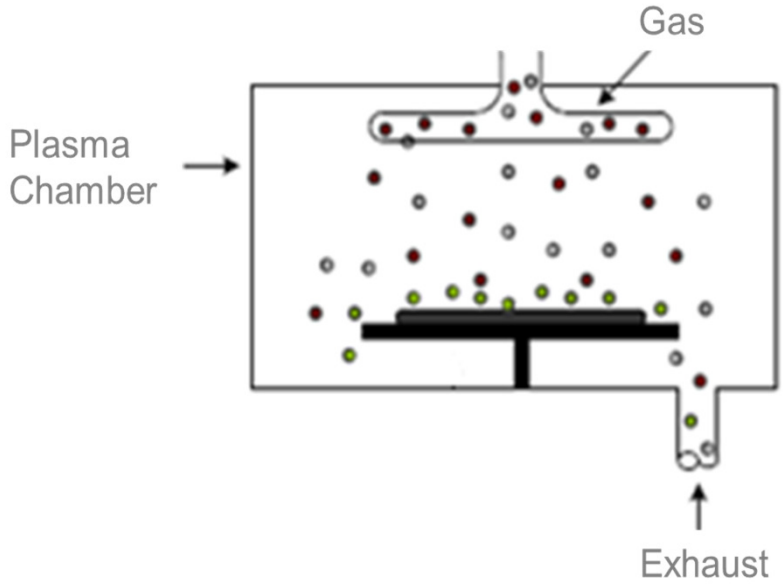

Figure 2 Dry Treatment with O2 mixed with innocuous H2O, H2 or other gases

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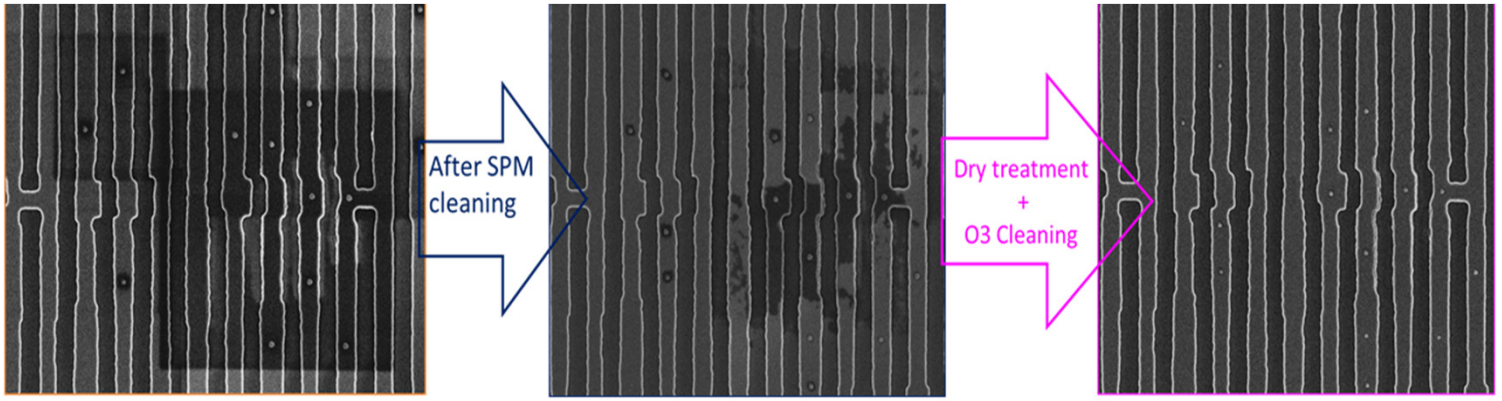
Data & Analysis

Dry Treatment Effect on Scan Damage

SPM (a Sulfuric – Peroxide Mixture) cleaning method tends to relieve or remove scan damage partially, but O3 cleaning (an alternative of SPM to prevent surface haze formation), seems no effect on it. But it's found that O3 cleaning with dry pretreatment could remove the scan damage completely.



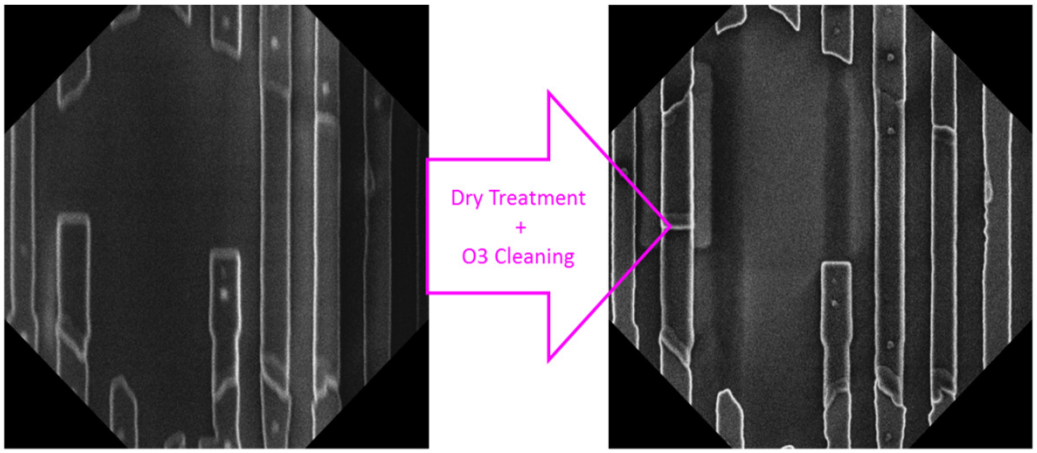
a. after O3 cleaning without dry treatment b. after SPM cleaning c. after dry treatment and O3 cleaning

Figure 3 Dry Treatment Removed Scan Damage induced by Etch Repair

Data & Analysis

Dry Treatment Effect on Scan Damage

Darken in CDSEM images may be not the only way of showing scan damage issues, Since we have once encountered image vibration phenomenon, highly suspicious as another behavior of scan damage. Conventional O3 clean doesn't work on it, but it has been removed by O3 clean with dry pretreatment assistance.



a. Vibrational Image due to scan damage

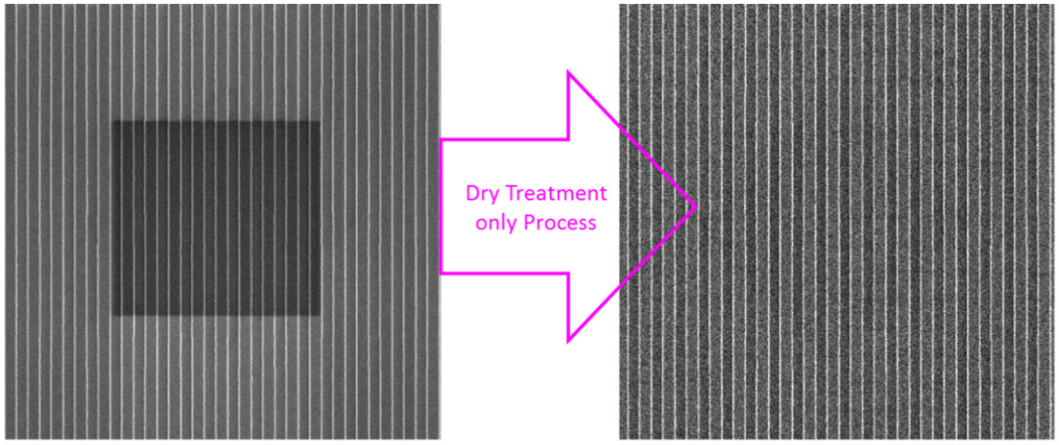
b. Solved by O3 cleaning with Dry Pretreatment

Figure 4 Dry Treatment Solved Image Vibration induced by Deposition Repair

Data & Analysis

Dry Treatment Effect on Charge Effect

There are similarities between scan damage and charge effect induced by CDSEM scanning, and it's found that charge effect could be cleared by dry treatment only. On the other hand, Conventional O3 clean can also remove the charge effect easily.



a. Charge Effect due to CDSEM scanning

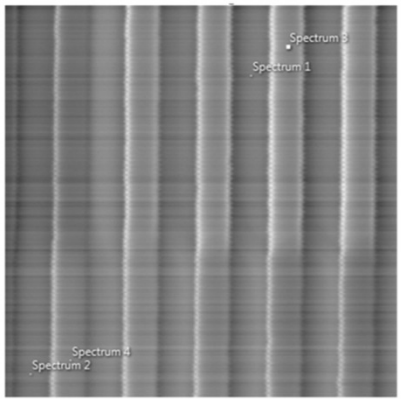
b. Charge Effect Removed by Dry Treatment Only

Figure 5 Dry Treatment could Remove Charge Effect

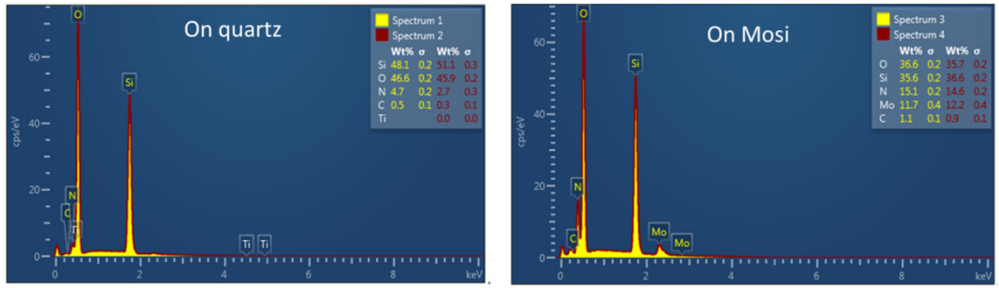
Data & Analysis

X-ray Composition Analysis of Scan Damage and Charge Effect

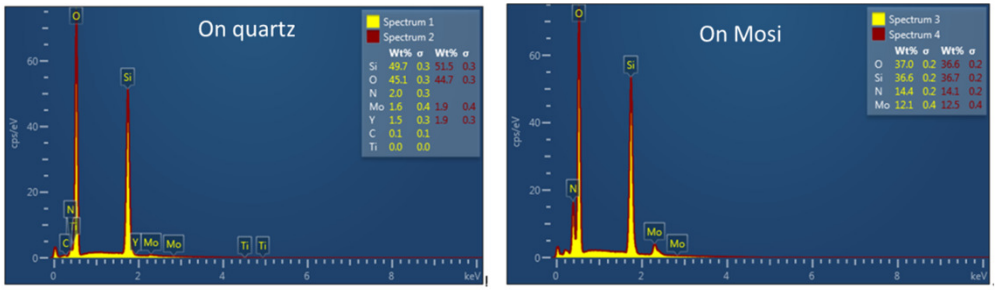
X-ray Composition Analysis results show that Carbon and Nitrogen elements increased for both scan damage and charge effect.



Spectrum 1 : on quartz in abnormal area
Spectrum 2 : on quartz out of abnormal area
Spectrum 3 : on Mosi in abnormal area
Spectrum 4 : on Mosi out of abnormal area



a. X-ray composition analysis of scan damage issue



b. X-ray composition analysis of charge effect issue

Figure 6 X-ray Composition Analysis Results of Scan Damage and Charge Effect

Data & Analysis

Mechanism for Dry Treatment

paper poses emitted secondary electrons absorbs hydrocarbon molecular, which has a hydrophobic property that is hard to clean. Dry treatment may change its hydrophobicity to hydrophilic.

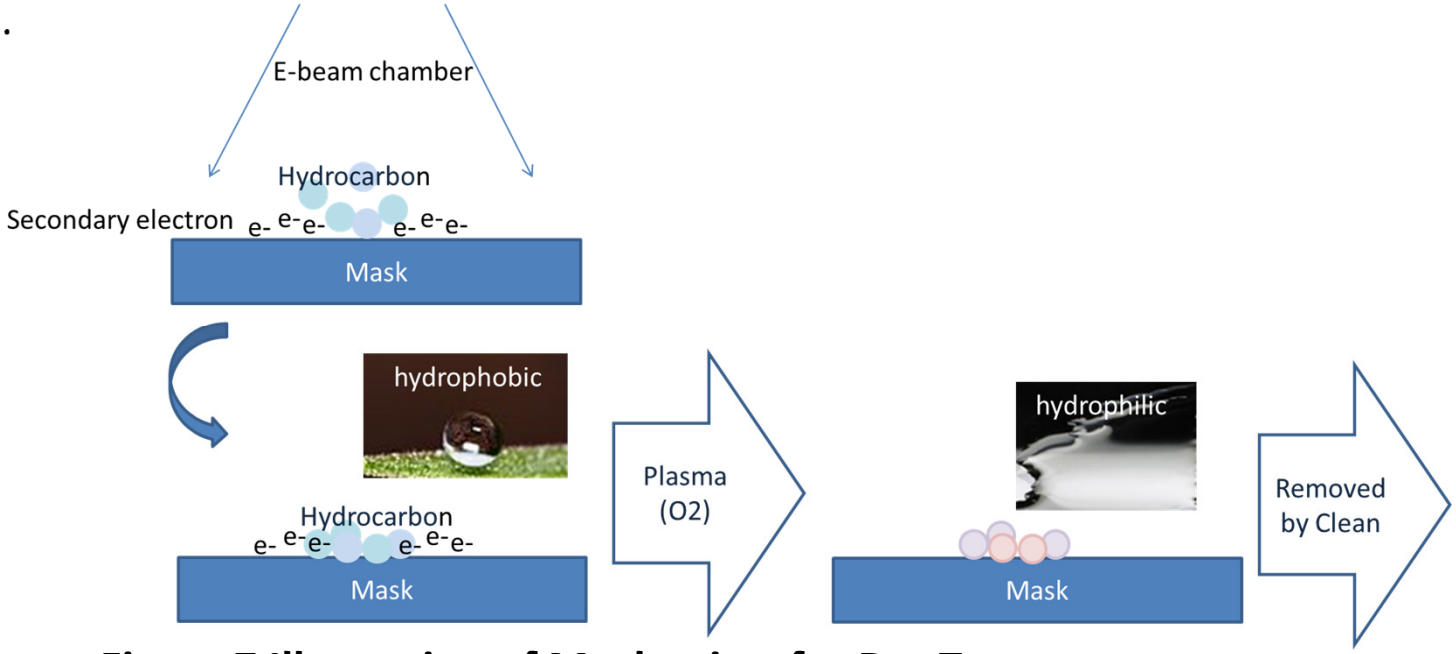


Figure 7 Illustration of Mechanism for Dry Treatment

Data & Analysis

Study on Dry Pretreatment Effect on Cumulative Doses of Scan Damage

Scan damage and charge effect is assumed to come from the similar mechanism, related to electron beam. We studied dry treatment and other wet clean methods effect on cumulative doses of scan damage. Results prove dry pretreatment is actually a dry clean method, which would gain double clean effect together with wet clean.

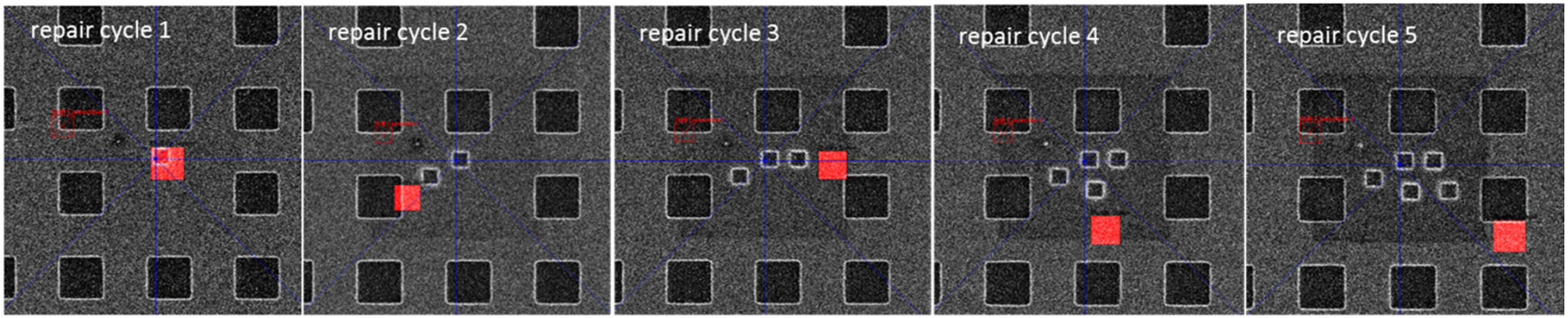
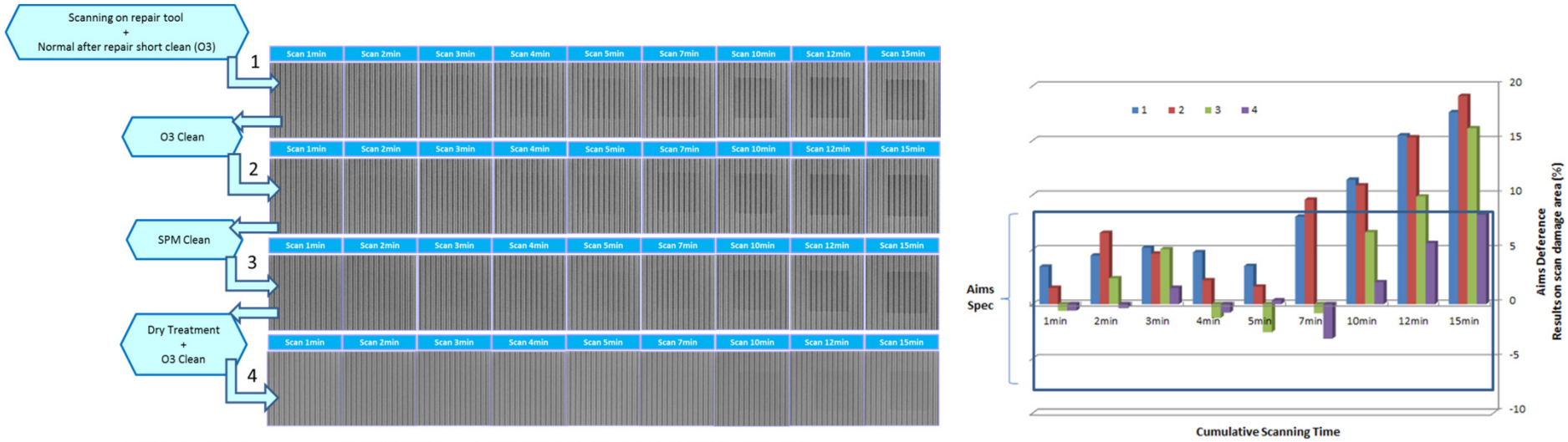


Figure 8 Scan Damage Accumulations in Repair Cycles

Data & Analysis

Study on Dry Pretreatment Effect on Cumulative Doses of Scan Damage

Clean with dry pretreatment provides stronger clean effect than SPM clean and O3 clean, but it still has an impassable limit for scan damage accumulation.



a. Process Flow b. CDSEM images with Cumulative Doses of Scan Damage c. Aims Deference Results with Cumulative Doses of Scan Damage

Figure 9 Dry Treatment Effect on Cumulative Doses of Scan Damage

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Summary

Dry treatment method helps to remove scan damage and charge effect induced by electron beam source. It provides a substantial increase in cleaning capability on ArF PSM mask.

Acknowledgement

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Thank You!