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DisCharge: Spin-On Anti-Charging Agent for Electron Beam Lithography

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Abstract

This report documents the chemical DisCharge from DisChem, Inc. used as an anti-charging agent for electron beam lithography at the University of Pennsylvania Singh Center for Nanotechnology Quattrone Nanofabrication Facility. Charge accumulation while exposing atop an electrically insulating substrate can severely impact positional accuracy of the beam yielding poor litho. Using DisCharge has been shown to reduce charge accumulation for insulating substrates such as fused silica pieces, glass slides, and PDMS for positive resists such as PMMA, ZEP520A, CSAR 62 and mr-PosEBR.

Keywords

DisCharge, DisChem, EBL, electron beam lithography, e-beam, e-beam lithography, anti-charging, anti-charging agent

Disciplines

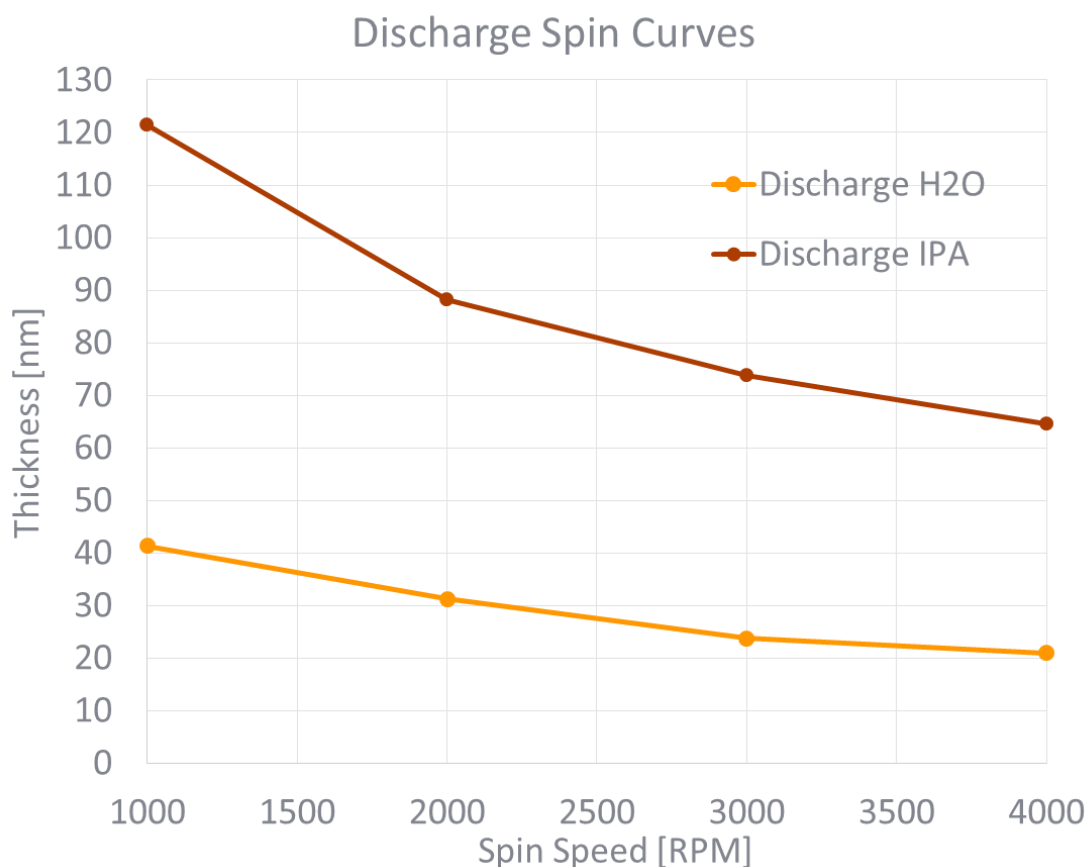
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Introduction

This report documents the chemical DisCharge from DisChem, Inc. used as an anti-charging agent for electron beam lithography at the University of Pennsylvania Singh Center for Nanotechnology Quattrone Nanofabrication Facility. Charge accumulation while exposing atop an electrically insulating substrate can severely impact positional accuracy of the beam yielding poor litho. Using DisCharge has been shown to reduce charge accumulation for insulating substrates such as fused silica pieces, glass slides, and PDMS for positive resists such as PMMA, ZEP520A, CSAR 62 and mr-PosEBR.

Spin Curves

DisCharge DI and DisCharge IPA, as the names imply, are provided as DI water or IPA as the main solvent. Using the J A Woolam Vase Ellipsometer, dispersion curves for use on the Filmetrics F40 and F50 were generated. Four inch Si wafers were then spun at different speeds to yield the following spin curves for the two formulations of DisCharge.



Application and Removal

1. Spin coat and pre-bake per the resist protocol.
2. Let wafer/sample cool to room temperature for 5-10 minutes.
3. Spin coat DisCharge a specific RPM for desired thickness for 60 seconds. No pre-bake is required. The thin film should have a gloss finish similar to a properly spun resist. If a matte finish is observed, it means the sample was too hot during application and the solvent evaporated too quickly. Follow removal instructions and re-apply DisCharge. The film does not dry. Be careful not to smudge the surface after spin coating.
4. EBL Tool: Mount sample and be sure the grounding clip is properly touching the sample surface. Expose pattern.
5. Follow removal any one of the instructions below and dry sample.
 - a. **Spin Rinse** Method Removal
 1. Using a spinner, set the spin speed to 3000 RPM for 60 seconds.
 2. Initiate spin. While spinning, use a rinse bottle to apply generous amounts of IPA (or DI water) followed by an N₂ blow dry.
 - b. **Sink Rinse** Method Removal: DI Water
 1. While firmly holding the sample, place sample in direct path of running DI water over a sink.
 2. Dry thoroughly with an N₂ blow dry
 - c. **Solvent Rinse** Method Removal: IPA
 1. While firmly holding the sample, place in direct path of an IPA stream using a rinse bottle over a cup sink or beaker to capture the solvent. Do not pour solvents down the drain.
 2. Dry thoroughly with an N₂ blow dry
6. Develop the resist as normal.

Evidence of DisCharge as an Anti-Charging Agent

The following experiments provide evidence of DisCharge as an anti-charging agent using the Elionix ELS-7500EX 50 keV at the QNF. Preliminary test structures are contrast curve patterns that consist of 60 micron squares exposed at different dose using a 20 nm beam step size (shot pitch) with a 1 nA beam current.

300 nm PMMA 950 A4 atop 1 mm PDMS on bulk Si

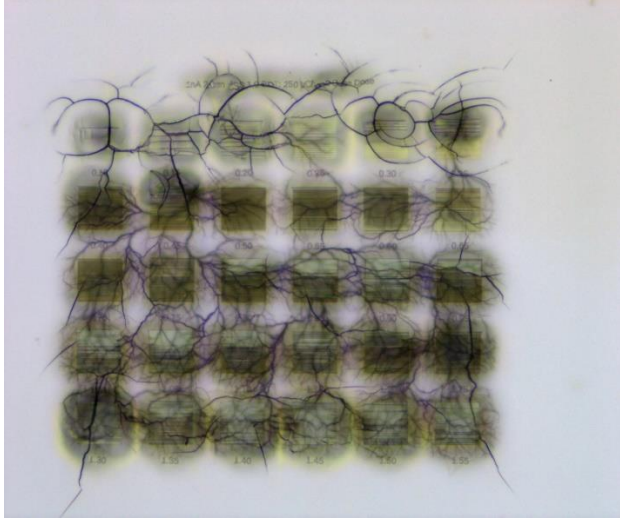


Figure 1a. Without DisCharge, charge accumulation and sudden charge dissipation by exceeding the dielectric breakdown strength of the PDMS to the Si substrate is observed as cracks in the PDMS.

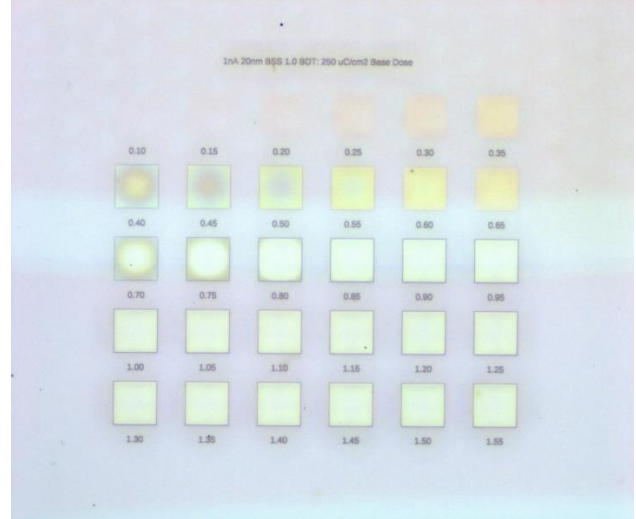


Figure 1b. With DisCharge, no charge accumulation is observed. The structure appears as expected with no harm to the PDMS from sudden dielectric breakdown.

300 nm mr-PosEBR atop Glass Slide

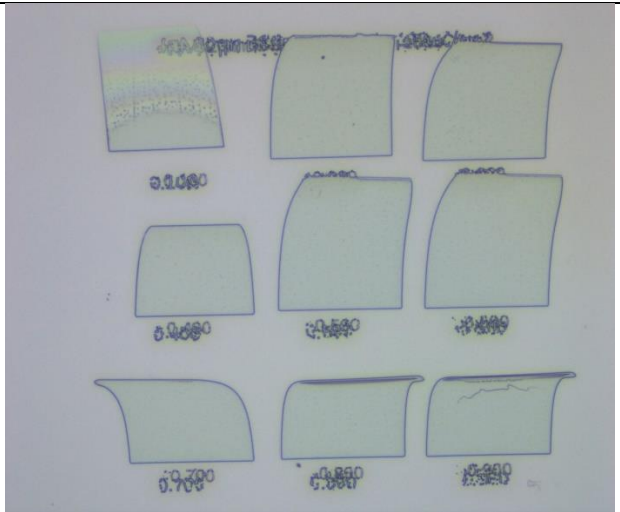


Figure 2a. Without DisCharge, charge accumulation leads to poor shape fidelity of the contrast curve pattern.

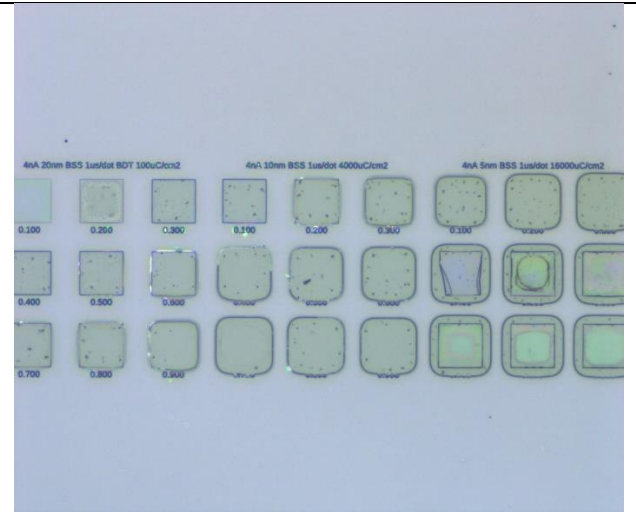


Figure 2b. With DisCharge, no charge accumulation is observed. The structure appears as expected. Crosslinking of the positive resist is especially observed at high dose.

200 nm ZEP520A atop Glass Slide

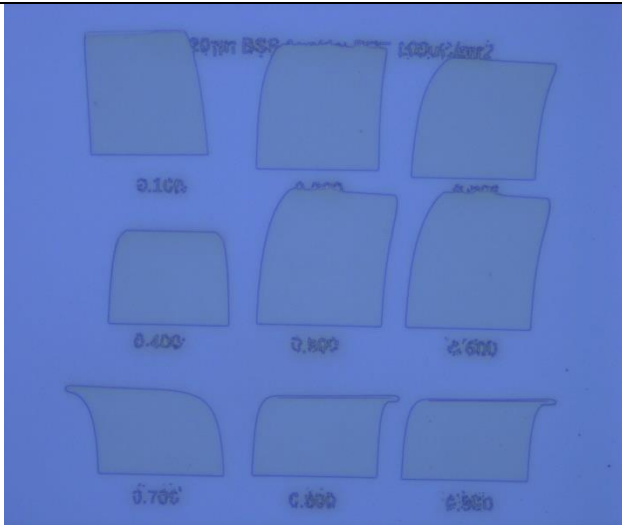


Figure 3a. Without DisCharge, charge accumulation leads to poor shape fidelity of the contrast curve pattern.

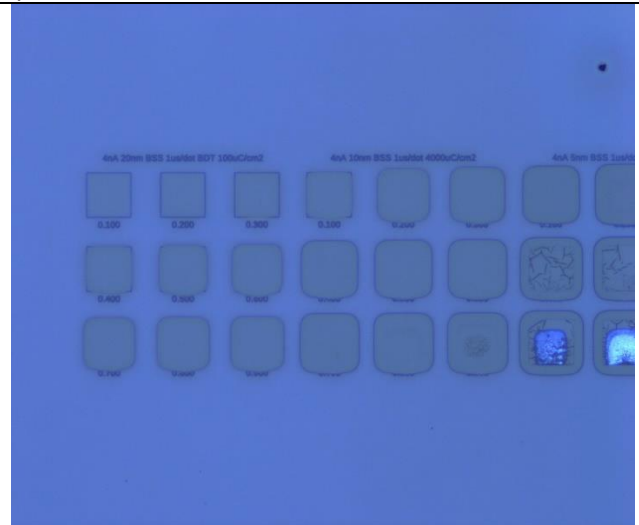


Figure 3b. With DisCharge, no charge accumulation is observed. The structure appears as expected. Crosslinking of the ZEP520A resist is especially observed at high dose.

300 nm CSAR 62 atop Glass Slide

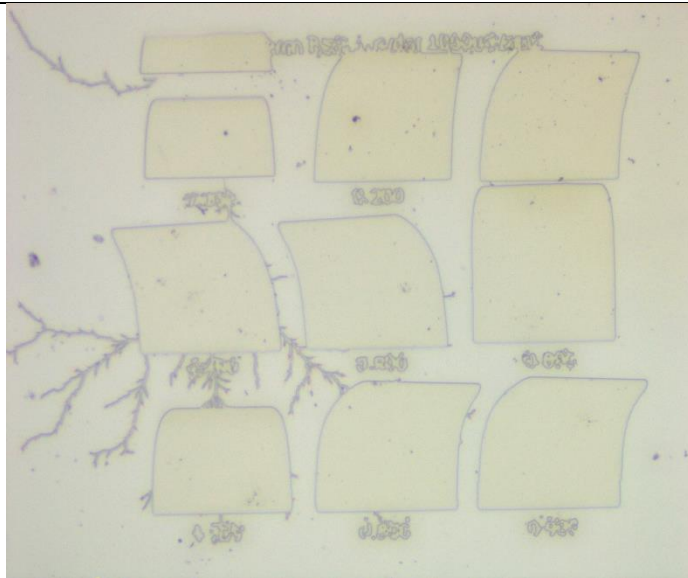


Figure 3c. Without DisCharge, charge accumulation leads to poor shape fidelity of the contrast curve pattern.

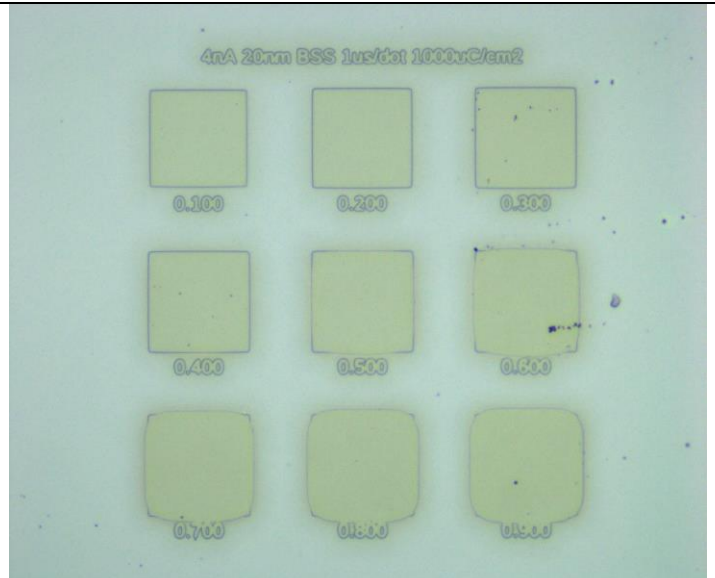


Figure 3d. With DisCharge, no charge accumulation is observed. The structure appears as expected. Crosslinking of the ZEP520A resist is especially observed at high dose.

Impact of DisCharge at the Nanoscale

DisCharge was also tested for its efficacy at the nanoscale using tower patterns exposed in a dose matrix using 300 nm ZEP520A atop fused silica. The tower patterns consist of 300 nm line space patterns at various pattern densities.

300 nm ZEP520A atop Fused Silica



Figure 4a. Without DisCharge, charge accumulation leads to poor shape fidelity of the tower patterns.

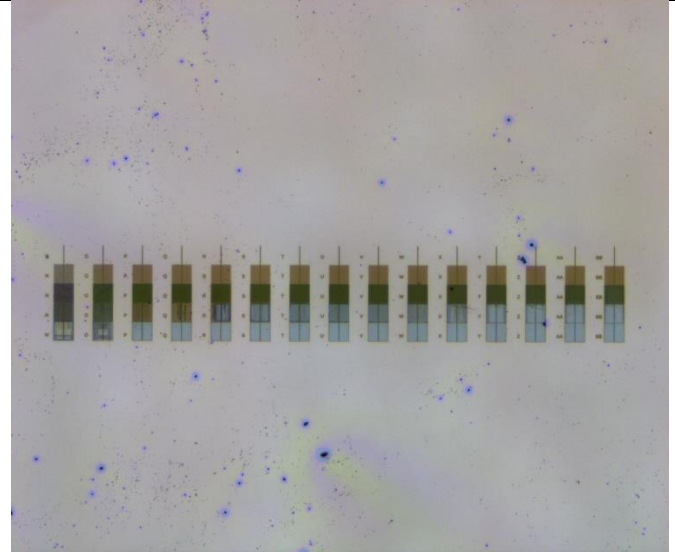


Figure 4b. With DisCharge, no charge accumulation is observed. The structure appears as expected.

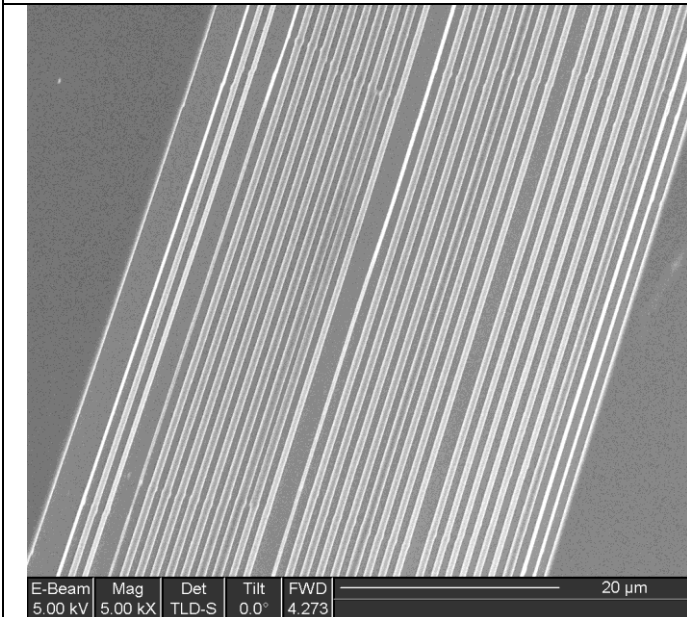


Figure 5a. Without DisCharge, charge accumulation leads to poor shape fidelity. The line pitch is not as expected.

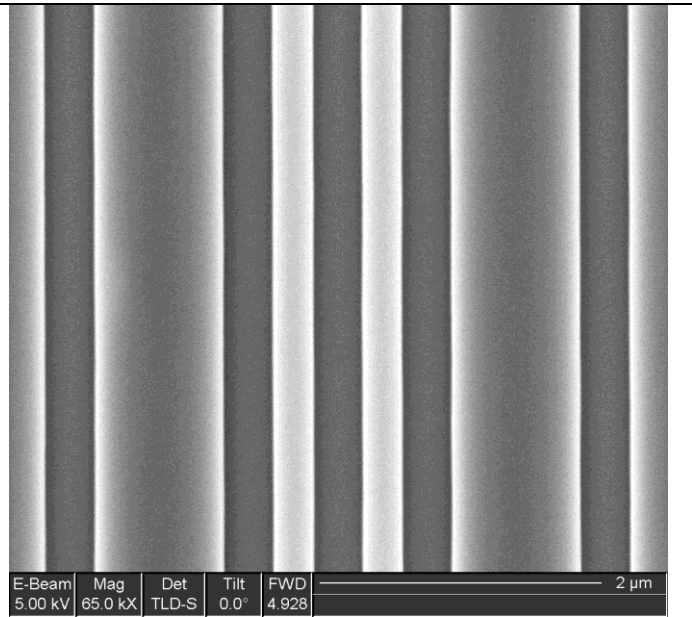


Figure 5b. With DisCharge, the 300 nm line-space is as expected. The lines are straight and appear to be exposed at the desired dose.

Acknowledgements

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