Line Width Roughness Control on Resist Process for EUV Patterning

Introduction
Controlling line width roughness (LWR) is a critical issue in extreme ultraviolet lithography (EUVL). High sensitivity, high resolution, and low LWR are required for EUV lithography resist. In order to achieve optimal properties simultaneously through chemical tuning. The track process is one of the factors that impacts LWR. Enhancing the track processes used in EUV lithography is necessary to control LWR.

Evaluation Conditions

- **Center/Developer**
  - System: CLEAN TRAX ACT™ 12 (Tokyo Electron LTD)
  - Resist: EUV novolac, film thickness: 560nm
  - Developer solution: TMAH, TMAH
  - Rinse solution: FIRM™ Extreme and SPC487

- **EUV Exposure tool**
  - System: Alpha extreme tool (ASML)
  - Illumination: NA 0.25, 6th, 7th, Conventional

- **Measurement**
  - SEM / Hitachi CS4000

Evaluation Matrix

- **Experiments Process Flow**
  - Process-A: Initial Developer
  - Process-B: FIRMTM Smoothing
  - Process-C: Devon Optimization

- **Summary**
  - Three techniques were found for LWR improvement; DEV process, FIRM and Smoothing.
    - LWR is improved up to 8% by development process optimization.
    - Up to 7% LWR improvement is confirmed by FIRM process, the effect depends on the FIRM chemical.
    - Smoothing process improves LWR 10-12%, the improvement is 16%.

Evaluation Results

- **Result Plots**
  - LWR was improved by pattern profile control
  - Student's t-test proved significant difference
  - All combined Process C shows the best result; LWR was improved 36.8%.

Best Process with Trilayer Resist

- **Power Spectra Density Analysis**
  - Tri-layer process, DEV process optimization and FIRM are effective in high frequency region.
  - Smoothing process shows improvement in wider region of frequency, especially from middle to high.

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Authors:
- Shinichiro Kawakami, Lior Hull
- TEL Technology Center, America, LLC
- Shannon Dunn
- Tokyo Electron America, Inc.
- Karen Petrillo, George Huang, Dominic Ashworth,
- Liping Ren, KY Cho, Stefan Wurm
- SEMATECH