Abstract

In this work, a 50 Kv electron beam lithography system has been used to pattern a wide range of nanometer scale geometries. A proximity correction software tool has been successfully applied to reduce pattern distortions.

Background

In recent years, electron-beam lithography has emerged as a serious contender for mainstream high-resolution nanofabrication in areas ranging from electronics, optics, solar cells to biomedical devices and DNA chips (Jugessur 2013). E-beam spot lithography, which writes at a speed of over 120 times faster than conventional techniques, is contributing to this rise (Jugessur, Yagnyukova, & Aitchison 2011).

Our main research investigated the effectiveness of BEAMER’s proximity correction modules, which “fracture” a design by dividing it up into smaller shapes, and subsequently varies the energy of electrons on different parts (Altissimo 2010). However, this method is not without drawbacks. Lithography scatter while travelling through the Si substrate, a phenomenon called “backscattering” or the “Proximity Effect” (Altissimo 2010). The effects are apparent on densely packed structures and at the corners of various designs, resulting in pattern distortions (Altissimo 2010).

The UMI possesses a state-of-the-art tool for electron-beam lithography, the Raith VOYAGER. The tool is capable of fabricating structures down to 10 nanometer, which is about 10,000 times smaller than the size of human hair. A software tool called Layout BEAMER was used to correct for pattern distortions.

To reduce the problem of backscattering, BEAMER offers the proximity correction (PEC or Corner-PEC) modules, which “fracture” a design by dividing it up into smaller shapes, and subsequently varies the energy of electrons on different parts (Altissimo 2010). Our research investigated the effectiveness of BEAMER’s proximity correction modules.

Methods and Process Flows

Lithography is the process of transferring a computer-generated design to a resist, usually PMMA. Subsequently, MBK-developer solution washes away the selected parts of the positive resist used in this experiment.

1. Preparing wafer: Si wafers cut using diamond lathed and diced, cleaned with acetone, water, methanol, and isopropyl alcohol (IPA).
2. Spin-coating: Poly methyl methacrylate (PMMA) deposited on wafer, which is spun at 3000 rpm.
3. Pre-exposure: Electron gun focused on any particle. Fine positioning, focus, stigmation, and stage movements programmed.
4. Exposure: Electron beam on wafer in VOYAGER, creating desired design.
5. Developing: Wafer immersed in minute of methyl isobutyl ketone (MIBK) and IPA for 30s, then stopper IPA for another 30s.
6. Viewing under SEM: Wafer baked back into VOYAGER to be visualized under scanning electron microscope (SEM), confirming lithography completion.

Results

- 90° angles in crosses well-defined in PEC
- Some under-exposure in corrected GDS
- Significant effect on acuteness of vertex angles

Conclusions and Applications

- Overall, the corner-PEC module improved shape fidelity and definition around right angle interior corners and acute angle exterior corners.
- Main application in optics: Research by Jugessur shows that Bragg grating structures have numerous applications in photonic devices (Jugessur 2013).
- Jugessur, Yagnyukova, Dou, and Aitchison designed a Bragg-grating waveguide fabricated with e-beam lithography and RIE to sense biomolecules or fluids (Jugessur, Yagnyukova, Dou, & Aitchison 2012).
- Other applications include solar cells, lab-on-a-chip, and integrated circuits.

References/Acknowledgements

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