Mask pattern optimization technology that extends life of current optical lithography

Improving the accuracy of lithography for LSI by approximately 20 %

We have developed a mask pattern optimization technology that improves the accuracy of LSI lithography by approximately 20 %. 30-nanometer generation lithography with ArF laser uses various technologies for achieving higher resolution such as immersion lithography in which liquid is filled between lens and wafers to enhance the resolution, but it is approaching its limit. The purpose of this research project is to extend the lifetime of ArF immersion lithography by improving the LSI photomask.

The Sub Resolution Assist Feature (SRAF), which modulates printed images of the main pattern, has been used to improve the resolution and the accuracy of the main circuit patterns. However, optimization of SRAF placement is becoming increasingly difficult as lithographic exposure approaches its resolution limits.

Our new technology applies an adaptive search algorithm based on the optimal gradient method to optimize the placement of SRAF which improves positioning and enhances critical dimension (CD) accuracy by approximately 20 %. The developed technology opens the door to extending the life of current ArF immersion lithography to the next generation and beyond.

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AIST TODAY Vol.10 No.7 p.16 (2010)

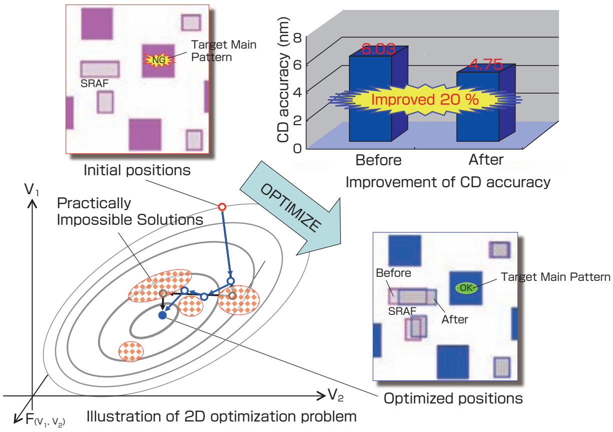

Illustration of initial and optimized patterns, 2D optimization problem and experimental results

Visualization of chemical reactions at atomic level

High-resolution transmission electron microscopy reveals the mechanism of chemical reactions between two fullerene molecules

We have developed high-resolution transmission electron microscopy to study the bimolecular reactions of fullerene and metallofullerene molecules in carbon nanotubes. Fullerene dimerization reactions start from an encounter of two molecules accelerated by phonons, photons, or electrons. The rate of reactions is often discussed from kinetics of the system and dynamics of molecules where the experimental conditions such as pressure, concentration, temperature, and existence of catalysts affect the system. Classic approaches to characterize such behaviors are based on the analysis of thermodynamics, spectroscopy, or microscopy that deal with enormous amounts or assembly of molecules in order to gain enough signal/noise ratios. Scientists have dreamed of capturing the very moment of reactions when the molecules change their structures. We have proved that the atomic resolution imaging of chemical reaction is indeed possible with moderate experimental conditions.

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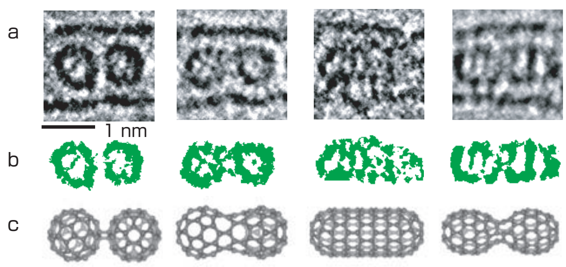
AIST TODAY Vol.10 No.9 p.15 (2010)



(a) Electron microscope images of C_{60} fullerene molecules
The molecules were irradiated with an electron beam and fused together by dimerization. The electron doses increased from left to right, and the chemical reaction proceeded.
(b) Image emphasizing contrasts (light and dark) of the molecules
(c) Model structures of the molecules