Sentaurus Lithography (S-Litho)

Predictive modeling of lithographic processes

Sentaurus™ Lithography (S-Litho) represents the industry standard in lithography simulation for semiconductor process development and optimization in advanced memory and logic applications.

It covers a wide range of patterning techniques such as proximity printing, deep ultraviolet (DUV), extreme ultraviolet (EUV), and electron beam (e-beam) lithography. Process-limiting effects within the imaging system of an exposure tool can be thoroughly analyzed, taking the impact of mask and substrate topography on photoresist patterning into account. Interfacing S-Litho with TCAD tool such as Sentaurus Topography enables seamless modeling of complex integration techniques such as double-patterning. The link between S-Litho and Proteus™ tools accelerates the development of optical proximity correction (OPC) solutions and supports the verification flow through automated hotspot analysis, significantly reducing cycle time.

Technology simulation plays an invaluable role in the field of advanced process development and optimization. Simulation effectively minimizes experimental engineering lots and short-loop experiments, resulting in accelerated process development, considerable cost savings, and a faster time-to-market.

S-Litho provides all the modeling capabilities necessary to enable engineers to make precise and reliable predictions on the performance of lithography processes and strategies. Individual modules of S-Litho address challenges in all relevant areas.

Figure 1: The S-Litho GUI provides full access to all simulation set-up parameters and enables an efficient and powerful analysis of results

S-Litho Benefits

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EUV Lithography Simulation

EUV lithography has been introduced into high volume production for printing the most critical features at the N7 technology node. It becomes mandatory to understand and accurately quantify effects which are caused by the EUV specific characteristics of the image and resist pattern formation process. Simulation enables complex sensitivity studies to assess appropriate compensation strategies, validate compact models and develop OPC solutions.

EUV lithography specific simulation functionality includes:

- Non-telecentric illumination of the reflective EUV mask, including topography effects, pattern shift, shadowing, etc.
- Printability assessment of multi-layer defects
- Through slit aberration and source characteristics
- Stochastic modeling, line edge roughness (LER) characterization and prediction of nano-defects (Figure 3)
- Advanced EUV resist processes and novel materials such as metal-oxide cluster-based resists
- Coverage of high-NA projection and anamorphic imaging, addressing next generation EUV lithography challenges

Figure 3: Stochastic simulation results. Single run result with LER (left); contour results of multiple runs (middle); localized nano bridge defect (right)

Electron-beam (e-beam) Lithography Simulation

Traditionally, e-beam lithography is used to define the pattern within the absorber layer on photomasks. Moreover, it can be applied to direct-write device-specific structures on the substrate (mask-less lithography), offering an alternative to DUV/EUV lithography during device prototyping. S-Litho addresses both use models for e-beam assisted patterning, mask-writing as well as wafer direct-write. Simulation is based on characteristics of electron scattering in the potentially inhomogeneous substrate. A detailed understanding of the mask absorber patterning process and resulting mask properties such as corner-rounding and slide wall angle become essential for creating models deployed in full-chip optical proximity correction (OPC) and verification.

Automation and Parallelization

S-Litho offers numerous pre-defined analysis capabilities as well as supports a flexible, multi-dimensional parametric exploration of any given parameter space. State-of-the-art multi-core processors or compute clusters can be used to parallelize computations and

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