

PSM Create and PSM Check

Alt-PSM technology for tighter control of chip performance and increased yield

Product Overview

The Sub-Wavelength Gap – the gap between IC feature sizes and the wavelength of the light used to pattern them – emerged at the 0.18 micron process node and widened at 0.13 μ making advanced mask synthesis techniques a necessity. At 0.13 μ and below, optical distortions and other lithographic effects cause larger features to deform and smaller features to disappear altogether. The resulting variations can significantly decrease performance or lead to yield loss. Mask synthesis has evolved as the solution to this problem. Mask synthesis includes resolution enhancement techniques (RET) such as optical proximity correction (OPC) and phase shift masks (PSM), and makes it possible to print features that are considerably smaller than the wavelength of light.

Dark-field, double exposure alternating PSM (Alt-PSM) technology fulfills the demand for higher yield and improved performance in sub wavelength regime (see Figure 1). PSM Create and PSM Check provide a comprehensive PSM software solution to achieve next generation feature sizes using a phase shifting process. PSM Create places and optimizes phase shifters on gate and critical field interconnect to convert existing designs into phase-shifted designs to gain performance and yield. PSM Check is used during the design stage to verify the layout compliance to PSM process requirements and therefore to reduce issues during mask synthesis. PSM Create applies distributed processing to reduce the conversion time of PSM designs. PSM Create is a production proven software solution which has been deployed at 90nm and advanced process nodes for highly demanding semiconductor devices.

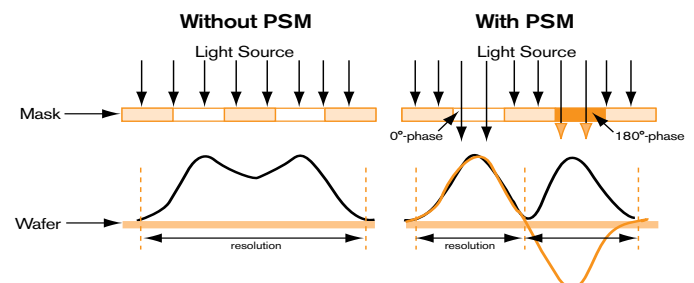


Figure 1: PSM technology enables sufficient image contrast to successfully print significantly smaller silicon features.

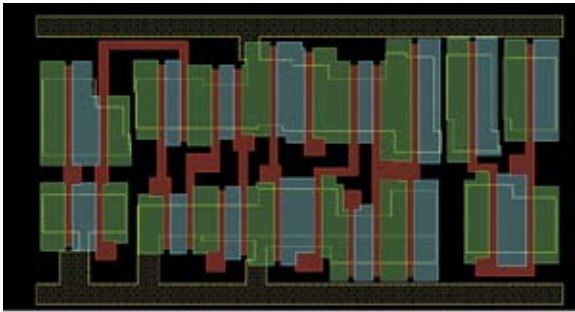


Figure 2: Phase-shifting on critical poly gate.

PSM Create

PSM Create is the next generation phase shift mask tool to automate the mask synthesis for Alternating Aperture PSM (Alt-PSM). For a given poly layer, PSM Create generates two masks: a binary mask and a phase-shifted mask. Working from design and process parameters, PSM Create places 0- and 180-degree phase-shifting structures onto the phase-shifted mask, which allow the printing of significantly smaller gate lengths. The correct generation of phase shifters is a computationally intensive process. Creating a working layout with no phase conflicts requires fast processing of geometrical and combinatorial algorithms. Using hierarchy management and distributed computing, PSM Create handles very large databases running microprocessor designs in hours, rather than days or weeks.

PSM Create supports several flavors of phase shifting. PSM Create can apply phase shifting on critical poly gate in order to reduce the gate length while improving the CD control (see figure 2).

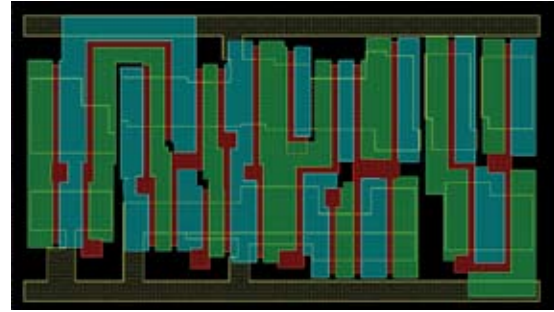


Figure 3: Phase-shifting on gate and critical field interconnect.

Phase shifting on gates increases the performance and reduces the leakage power of IC designs (see Figure 4). PSM Create can also apply phase-shifting on other critical poly features such as minimum dimension field-poly interconnect (see figure 3). Phase shifting on minimum dimension field-poly interconnect becomes important as the sub-wavelength widens. It enables aggressive wire patterning at 45 nanometers and beyond by providing superior manufacturability and CD control.

PSM Check

PSM Check is the Alt-PSM verification tool. It is licensed separately from PSM Create, while 100% consistent with PSM Create: a layout qualified as Alt-PSM compliant by PSM Check can be converted with no errors by PSM Create.

PSM Check assists designing PSM-compliant cells and blocks, and it represents an essential component in a full-chip design sign-off flow (see figure 5 & 6)

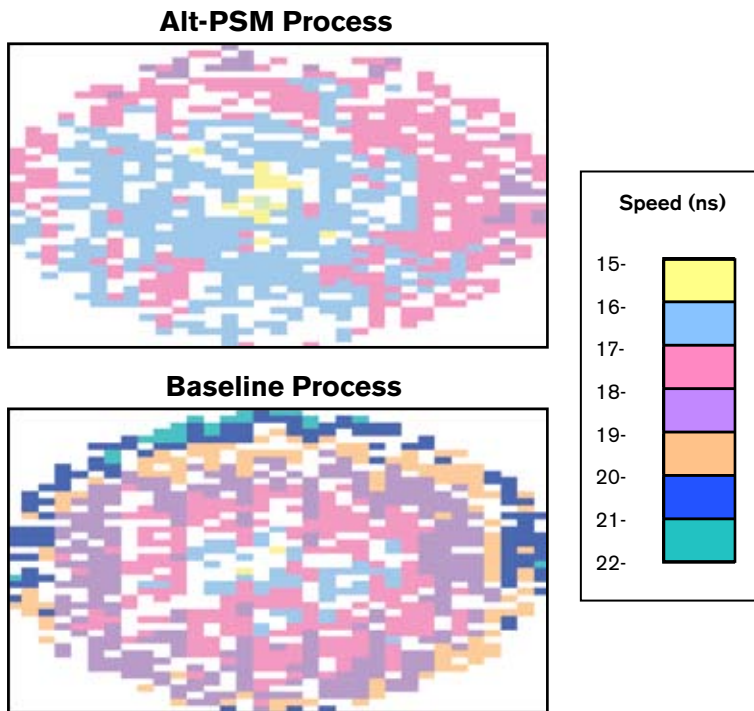


Figure 4: 90nm production wafer maps showing 10% improved chip performance with Alt-PSM.

Source: Chun-Chi Yu et al, "FPGA Chip Performance Improvement...", 5751-5756, BACUS 2005

PSM Create Benefits:

- A complete Production-Proven PSM solution enables printing of fast, small gates and other structures while minimizing variance
- Fast Alt-PSM design conversion through advanced layout hierarchy handling and distributed processing
- No compromise on lithography Quality-of Results (QoR) in order to complete phase coloring, by always enforcing the minimum shifter requirements
- Automatic coloring conflict resolution by adjusting, when necessary, the preferred shifter geometries
- MRC and litho-aware placement ensures mask manufacturability
- Integrated phase-shifting design rule checking and correction
- Highly programmable architecture, allowing the definition of user-specified design rules for manufacturing and inter-exposure alignment tolerances
- Supports design-reuse by preserving existing shifters (e.g. memory core)

Phase conflict detected

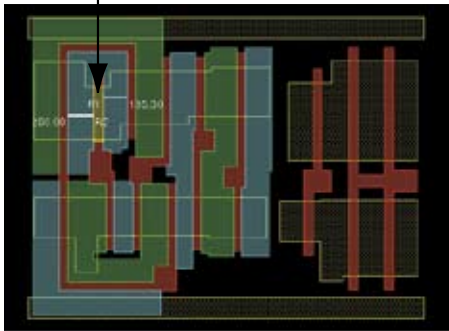


Figure 5: PSM Check detects phase compliance error.

Phase conflict resolved

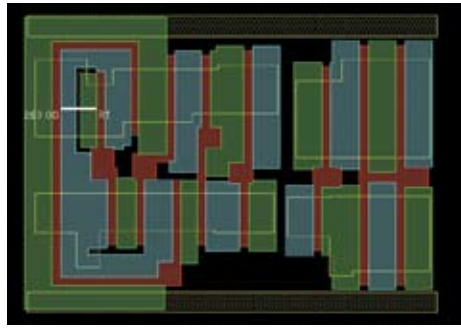


Figure 6: PSM conversion after phase conflict correction.

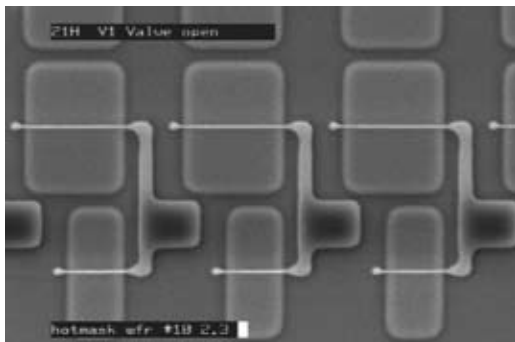


Figure 7: 50nm Transistor Gates Defined by Synopsys' Dark-Field Alternating Phase-Shift Mask.

Courtesy: Dr. M. Fritze, MIT Lincoln Laboratory

PSM Check Benefits:

- Informative and robust warning and error reporting of unresolved design rule violations and phase conflicts
- Detects phase conflicts early in the design and provides graphical feedback of conflict location

Production-Proven Technology

PSM-Create and PSM Check are production-proven tools based on Synopsys' patented phase-shifting technology which enables users to tightly control lithography resolution and enhance yields on high-performance chips for advanced 45-nanometer technology and beyond (see figure 7).

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Synopsys, Inc.
700 East Middlefield Road
Mountain View, CA 94043
www.synopsys.com