

Proteus WorkBench

Cockpit Tool for OPC Development and Optimization

Overview

Proteus WorkBench (PWB) is Synopsys' powerful cockpit tool for development and optimization of Proteus-based mask synthesis solutions. It provides a single user interface for building models for full-chip optical proximity correction (OPC), tuning correction recipes, and analyzing proximity effects on corrected and uncorrected IC layout patterns.

PWB offers an easy to use environment with access to a comprehensive set of tools, enabling fast turnaround time for accurately calibrated models and highly efficient OPC recipes.

As the resolution of existing lithography toolsets is pushed to a smaller feature size associated with more advanced technology nodes, the requirements for OPC are continuously increasing. Compact models calibrated against large experimental datasets need to accurately describe the lithographic performance for a huge variety of design patterns, and correction recipes need to be optimized with respect to an increasing number of control parameters.

With PWB, Synopsys provides a single environment that facilitates ProGen model building, Proteus OPC recipe generation and optimization, layout visualization and editing, verification, and other resolution enhancement technique (RET) functions. PWB combines ease-of-use with high efficiency, resulting in a fast turnaround time for setting up production-ready mask synthesis flows.

Benefits

- ▶ Save engineering time through automated model calibration, tuning, and validation
- ▶ Optimize recipe parameters for unmatched full chip OPC and RET performance
- ▶ High-speed layout visualization and lithography analysis
- ▶ Seamless interfacing to Synopsys' metrology toolbox (Proteus Metrokit) and rigorous lithography process simulation suite (Sentaurus Lithography)

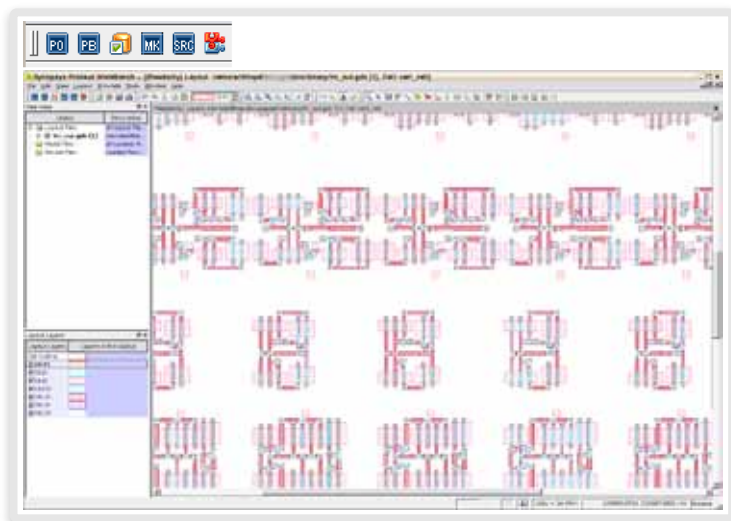


Figure 1: Proteus WorkBench – User interface and PWB toolbar

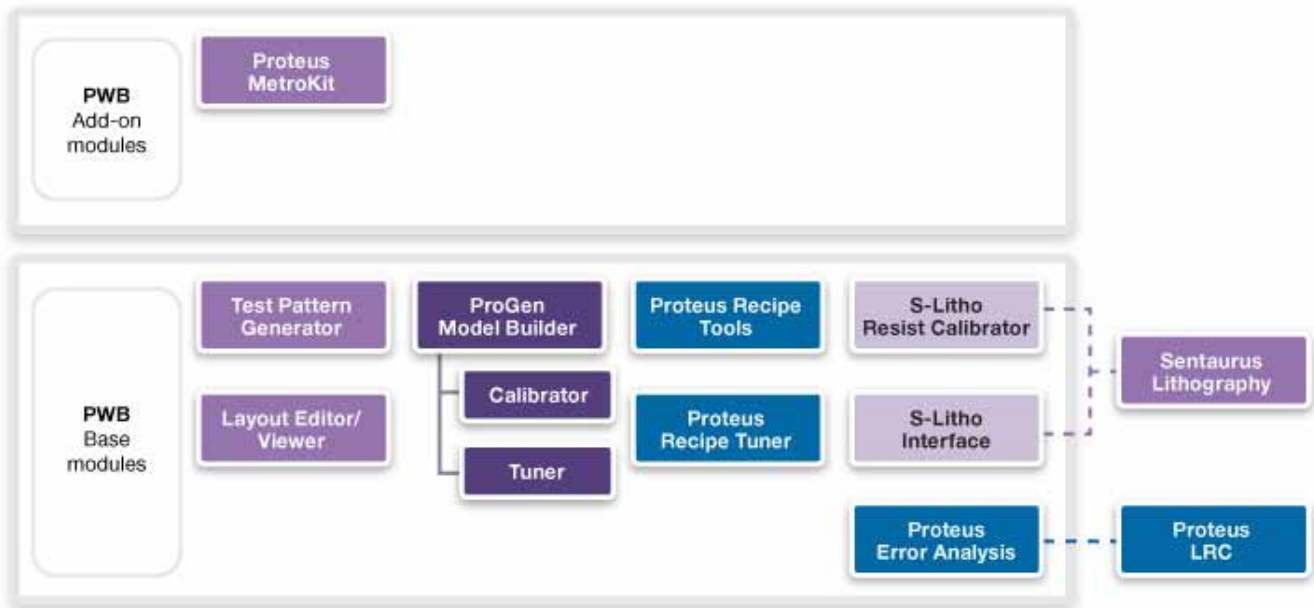


Figure 2: Proteus WorkBench - Module structure

Easy access to a comprehensive toolbox for OPC development and optimization

PWB offers a collection of powerful tools that allow engineers to further improve the quality of results of Proteus-based mask synthesis flows. Through the PWB toolbar, users can easily access those applications (Figure 1).

With a single click, GUI elements specific to the selected application are loaded, providing a customized working environment for the particular engineering task. Advanced users can enable multiple tools to address more complex problems.

PWB is fully programmable; users can modify windows, menus, toolbars, and add their own macros and scripts to extend functionality, turning PWB into a unique environment for individual OPC tasks.

Figure 2 shows the different modules available in PWB, as well as the links to other Synopsys products which significantly extend the application space of the tool.

Layout tools

Layout editing, viewing, and analysis

In its simplest configuration, PWB is a powerful, hierarchical layout visualization and analysis tool, based on Synopsys' IC WorkBench Plus. PWB is able to load large GDSII/OASIS files, offers easy exploration by fast zooming and panning capabilities, and allows users to interactively manipulate existing, or create new, layout pattern.

Highly accurate ProGen models – the same models used by all Synopsys Manufacturing tools – can be applied to quickly determine contours or aerial images (including intensity cross-section data) for a selected layout clip. This lithographic response allows a user to explore advanced OPC techniques or compare OPC performance under different model conditions.

For more information, please see the IC WorkBench Plus datasheet.

Test Pattern Generator (TPG)

TPG is a parametric-based pattern generator designed for lithographers and OPC engineers. It allows for the creation of test patterns to capture

lithographic and other process effects necessary for accurate model tuning and prediction. TPG generates all the necessary files for model calibration and recipe tuning, supporting an easy exchange of information between the various tools in the flow.

ProGen Model Builder (PMB)

ProGen models are empirical compact models reflecting the performance of a lithography process. Model parameters are determined by fitting experimental data. PMB provides individual tools for calibrating those parameters with a high degree of automation and tuning them for optimum performance. Thus, PMB allows for a significant reduction of the turnaround time, but maintains the high accuracy criteria of expert-calibrated models.

ProGen Model Calibrator (PMC)

The PMC module in PWB is a highly automated model calibration utility that guides the user through the individual setup steps, e.g. defining the lithographic process conditions, test patterns, and locating empirical data. Pre-defined search algorithms and cost

functions, as well as best practices and expertise, are built into the calibration routines to generate highly accurate models for use in OPC and RET.

ProGen Model Tuner (PMT)

The PMT module allows an intermediate user to tune model parameters beyond models coming from the Calibrator. Input data can be manipulated, e.g. by applying weights, cost functions freely chosen and modified, regression types and distributed processing schemes adjusted. Moreover, the user has more flexibility in selecting relevant model parameters and parameter ranges to optimize.

Proteus Tools

Proteus Recipe Tools (PRT)

The Proteus Recipe Tools represent a collection of different utilities that improve the efficiency of PWB for certain special applications.

The **DP Cluster** utility is designed to define the computational resources for distributed processing, usually done by an IT specialist. Once set up, PWB users can simply choose from a list of available computation clusters and start a job without having to worry about the complexity of distribution on multiple core processors.

Proteus Recipe Parameter Setup

provides a fully customizable GUI that allows users to easily define Proteus parameters in a development environment. Users can interactively eliminate parameter conflicts that usually only show up during run time and validate data integrity before launching a job.

Alternative to running Proteus on the entire layout, **Proteus Localized Processing** enables users to apply a correction recipe to a local area of interest and examine the corrected layout, dissection points and evaluation results.

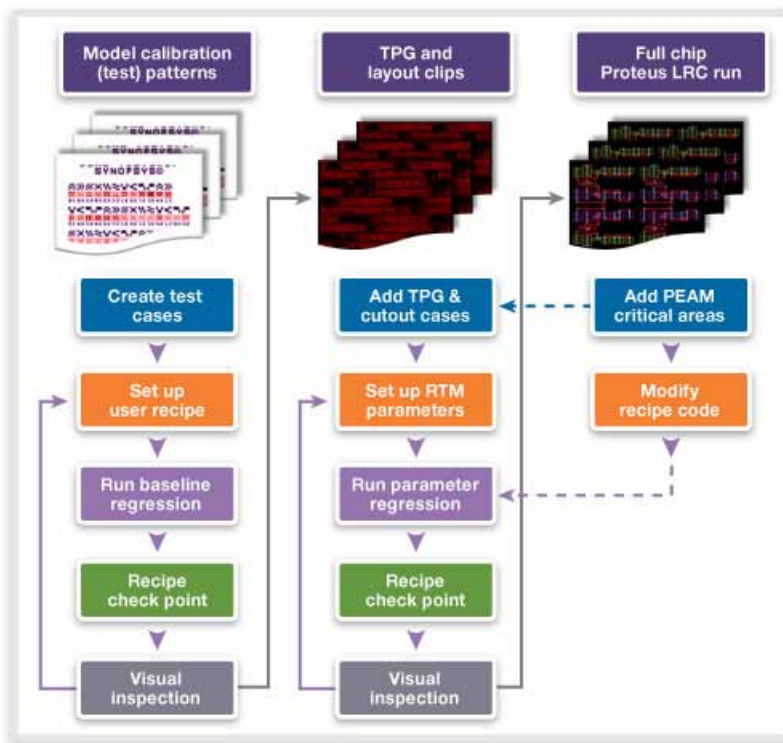


Figure 3: Typical strategies for Proteus recipes optimization

With the **Proteus LRC Test Case Generator**, specific rule violations or hotspots can be converted into test cases to replicate the problem and analyze it further. This enables users to debug and tune failure modes without re-running full-chip OPC.

Proteus Recipe Tuner Module (RTM)

The Proteus Recipe Tuner Module is a very powerful tool to optimize OPC recipe parameters – for instance, minimizing the CD variation or optimizing convergence or iteration count settings. In RTM, a user can set up “experiments” in which parameters are varied and the impact on the corrected layout is measured. Test cases can be constructed from test patterns using TPG, user-selected layout highlights, or Proteus LRC results. Figure 3 shows the three typical use cases supported by RTM for recipe development and optimization.

RTM offers “push button” optimization of recipes as well as full customization

of the tuning and assessment tasks, which can also be distributed across multiple processors.

Creating a full-suite of test cases enables a user to rapidly and consistently assess the impact of changes due to recipe parameter modifications, thus significantly improving the qualification process.

Sentaurus Lithography Interface

With shrinking process windows,

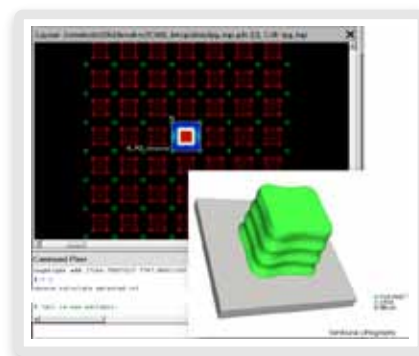


Figure 4: Sentaurus Lithography simulation results, 2D aerial image and 3D resist profile displayed in PWB

rigorous lithography process simulation plays an increasingly important role in manufacturing applications. PWB offers a seamless integration of Sentaurus Lithography (S-Litho) into its layout-centric environment. Rigorous simulation enables precise and reliable prediction of the performance of lithography processes, as well as layout modifications.

Results such as resist contours can be visualized together with the layout information, while complex numerical and algorithmic settings remain hidden in the background. Three-dimensional resist profiles and process window parameters are determined, and contour bands can be used to display the corresponding results in PWB, as shown in Figure 4.

S-Litho serves as an ideal verification tool for most critical areas or process conditions. For more information, please see the Sentaurus Lithography datasheet.

S-Litho relies on calibrated resist models, which capture customer-specific details of the resist process, such as wafer stack and resist film properties, post-exposure bake and development conditions, or metrology settings. Resist model parameters are determined by fitting simulation results against experimental data, e.g. CD measurements and profile cross-section information. The **S-Litho Resist Calibrator (SRC)** in PWB represents the front-end to S-Litho's calibration utility. It is used not only to display relevant layout components such as test patterns, but also to monitor and visualize the calibration progress, and to validate the resulting model.

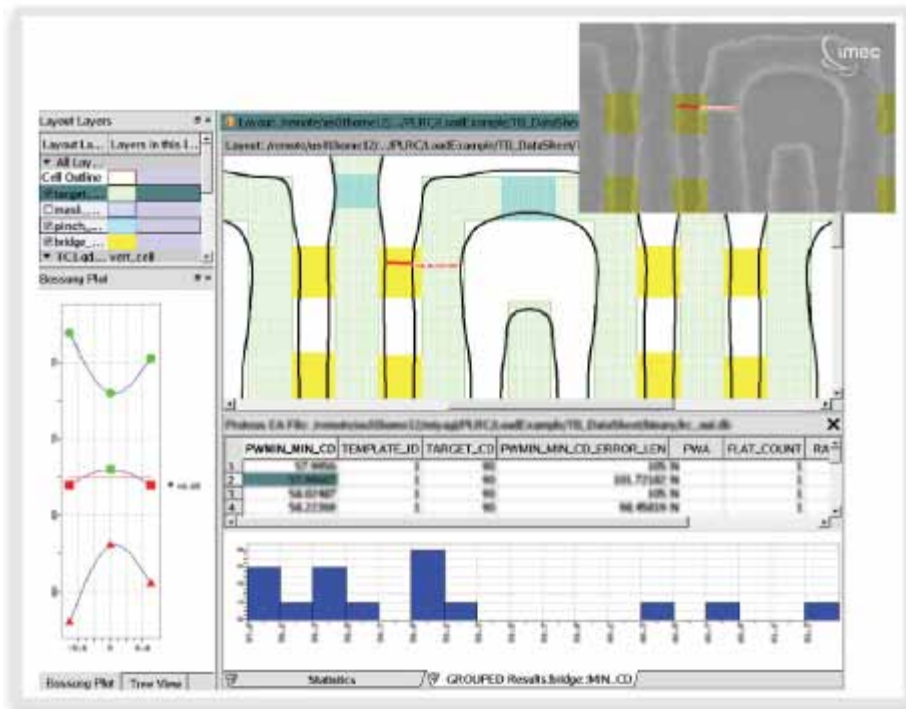


Figure 5: Proteus Error Analysis Module (PEAM) in PWB

Proteus Error Analysis Module

Lithography error review and analysis is supported using the Proteus Error Analyzer Module (PEAM), as shown in Figure 5. PEAM provides an intuitive and feature-rich GUI environment for driving to error locations, reviewing histograms, statistical summaries and Bossung plot analysis of the results. Errors can be sorted and filtered, classified, plot, and lithography modeling performed at those locations, either using a ProGen compact model or rigorous simulation by S-Litho. For more information, please see the Proteus LRC datasheet.

Proteus MetroKit

Proteus MetroKit is a toolset designed to facilitate and automate the process of interfacing with metrology tools, thereby minimizing tool downtime and maximizing engineering efficiency. The toolset provides the ability to generate test patterns for modeling, automate

the creation of metrology recipes for empirical data collection, reformat and analyze empirical data collected from the metrology tool for use with other Proteus applications, and create gauge files for model tuning. This product is offered as an upgrade option to PWB. For additional details, please see the Proteus MetroKit datasheet.

For more information about Synopsys products, support services or training, visit us on the web at: www.synopsys.com, contact your local sales representative or call 650.584.5000.

