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# Taurus-WorkBench

## Virtual IC Factory

Taurus-WorkBench satisfies a long-identified need in IC design, technology development and semiconductor fabrication: the availability of physical simulation tools in a natural, graphically based environment, facilitating their use in the evaluation of design alternatives, yield optimization and failure analysis. Growing industry acceptance of TCAD (technology computer-aided design) and other physical simulation tools has broadened their use from the R&D scientist to the front-line engineer. These new users have a single motivation: to solve real technology problems in the shortest time possible and at the lowest cost. This has long been the promise of physical simulation, and through Taurus-WorkBench it is further realized.

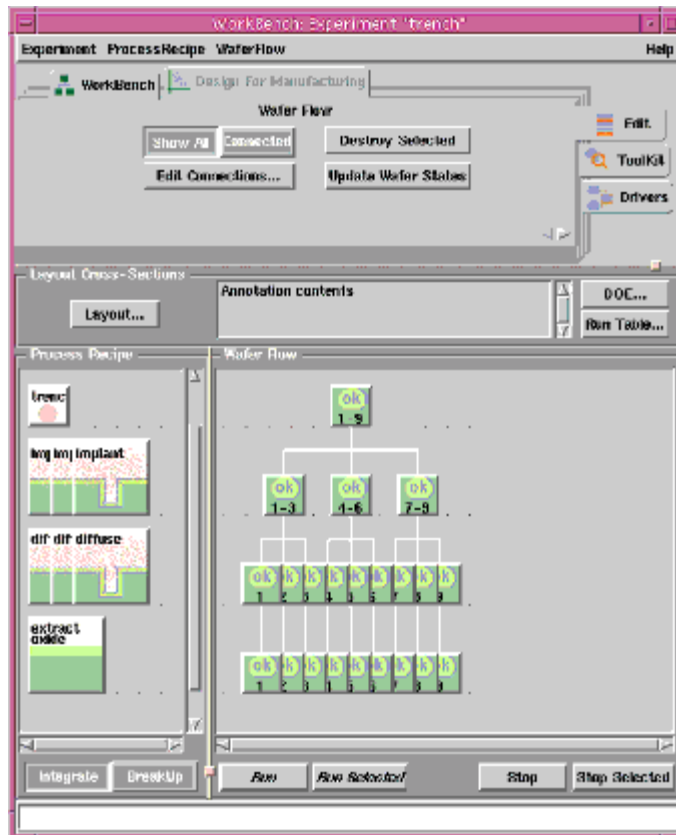
### TAURUS-WORKBENCH HELPS YOU:

- Optimize IC fabrication processes.
- Shorten product development cycle and time to market.
- Perform design for manufacturability and maximize yield.
- Evaluate design tradeoffs.

The goal of Taurus-WorkBench is for the semiconductor engineer to completely realize the power and competitive payoff of computer simulation: the integration of technology development, circuit design and IC manufacturing activities through physically based software tools resulting in high performance and lower-cost IC products.

Within Taurus-WorkBench, process flows, as well as device and circuit performance, can be simulated using a combination of physical simulation tools from Avant! and elsewhere. Execution moves automatically from one tool to another, with Taurus-WorkBench handling data management and providing updates on simulation status. Different design alternatives or sensitivities to process variations can be evaluated efficiently using the design of experiments (DOE) capabilities. Taurus-WorkBench manages the execution of all simulated wafer splits, either on a single computer or across a network of different systems. Built-in statistical analysis capabilities assist the user in problem diagnosis, such as studying correlations to identify the causes of parametric yield loss. For post-simulation data analysis, Taurus-WorkBench supports extensive graphical post-processing, ranging from visualizing structures following single process steps to plotting parametric variations across multiple wafer splits. Construction and use of response surface models allows rapid approximation of responses in a design space, which can then be further explored via optimization. For the first time, a strong feedback loop is provided among process development, circuit design and IC manufacturing.

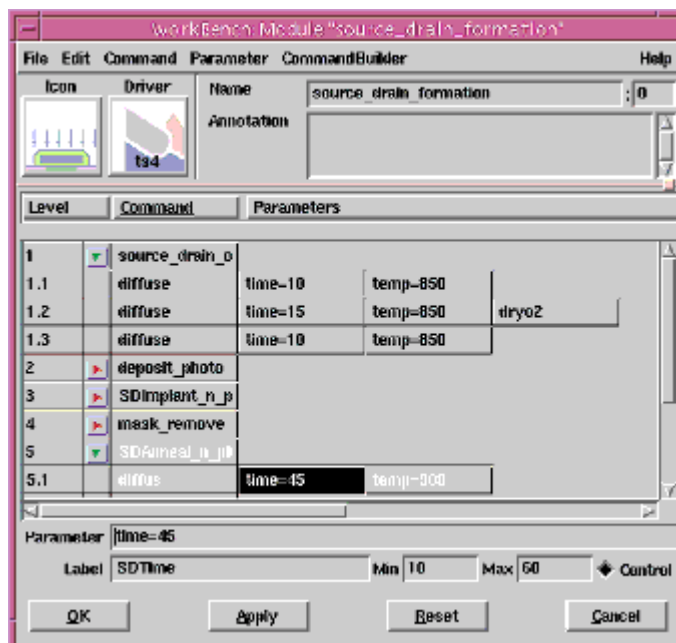
Taurus-WorkBench was developed in close consultation with physical simulation users at leading-edge semiconductor companies. This was done to assure the practical relevance of all functionality, as well as Taurus-WorkBench's robustness and suitability to fulfill real engineering needs.



Experiment window showing results.

### NATURAL, EASY-TO-USE GRAPHICAL USER INTERFACE

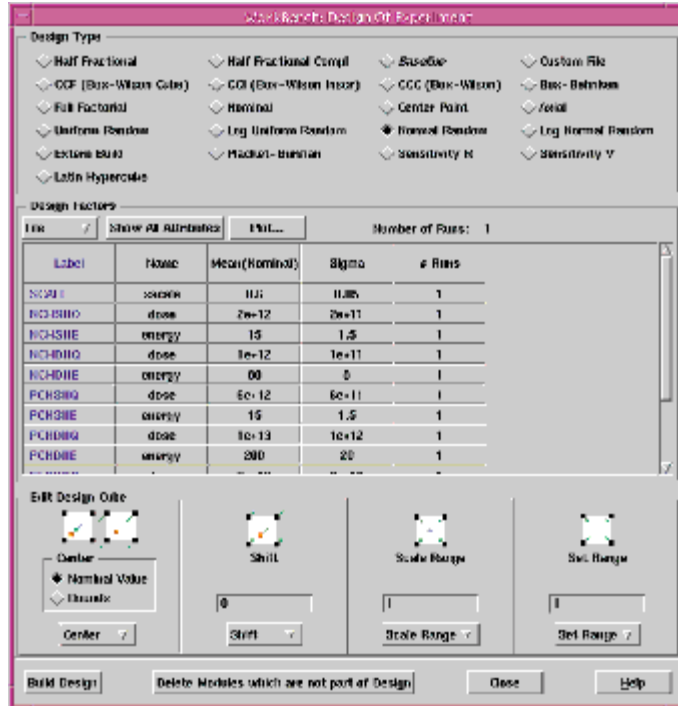
Taurus-WorkBench's revolutionary user interface removes much of the simulation burden. All d specification is handled through graphical menus, with information hierarchically organized in modules that contain information such as process steps or electrical test conditions. In addition simulator-specific controls and model requirements for different technology applications are archived in modules for convenient access, preserving design methodology and simulation expertise. Finally, to define the simulation flow, the user simply defines a sequence of simulation modules using interactive drag-and-drop operations. The result is an intuitive directed graph showing all simulation stages, as well as any splits that will be performed.



Module Editor window.

## EXTENSIVE DESIGN OF EXPERIMENTS (DOE) CAPABILITIES

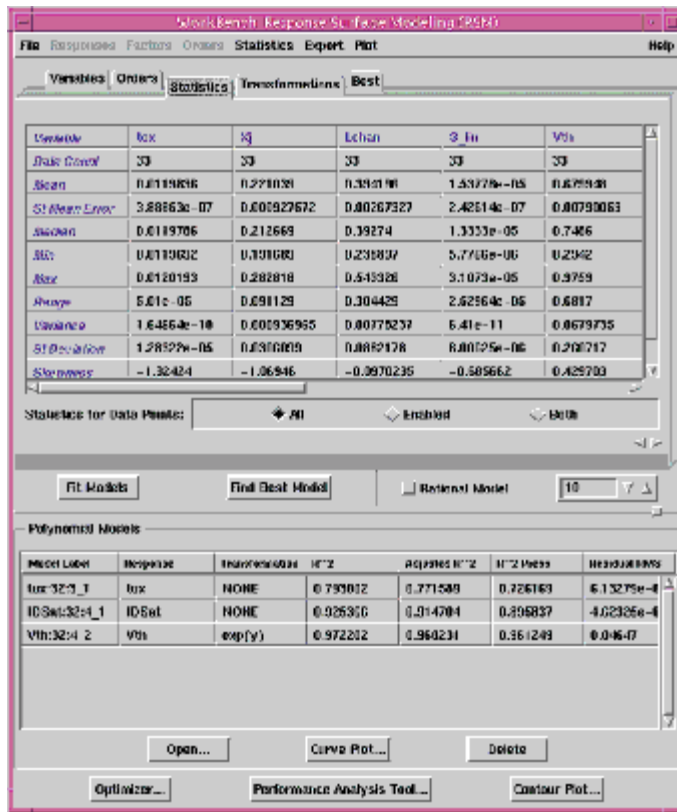
Taurus-WorkBench includes a complete capability for efficiently designing simulated experiments based on the number of input variables and parametric responses being studied. It allows the user to define the input variables of interest, the responses to monitor and the DOE method to be used. Taurus-WorkBench then automatically generates the simulation splits necessary to characterize responses. Once all splits have run, the design provides a sound base from which to generate response surface models (RSM) or to calculate meaningful statistical quantities. In this way Taurus-WorkBench provides the engineer with scientifically justified methods for efficiently and thoroughly understanding his technology and design.



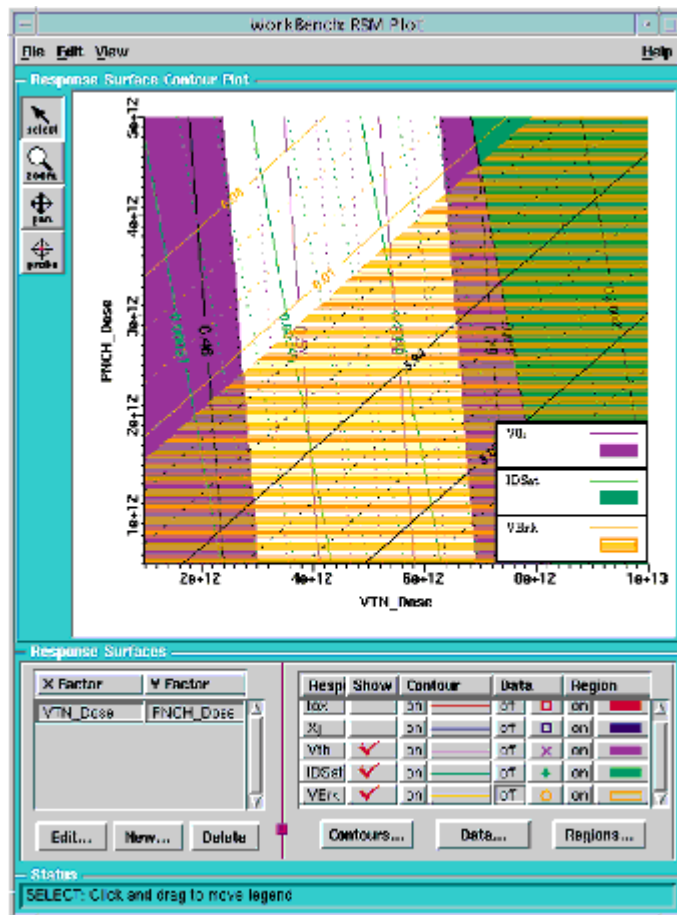
Design of experiments window.

## REGRESSION ANALYSIS OPTIMIZATION

Taurus-WorkBench includes several tools to support advanced design techniques. Through regression analysis, the user can generate a response surface model relating performances to design parameters. Providing product specifications, you can use Taurus-Visual to graphically determine acceptable design windows, or use optimization to obtain optimal designs.



Response Surface Modeling window.



RSM Contour Plot.

Design	Label	Name	ok 1	ok 2	ok 3	ok 4
✓	ARC	area	2e+12	2e+12	2e+12	2e+12
✓	VTN	noise	5.5e+12	5.5e+12	5.5e+12	5.5e+12
	VTN	energy	25	25	25	25
✓	VTN	area	5e+11	5e+11	5e+11	5e+11
✓	PRCH	energy	50	50	50	50
	VTN	noise	3e+12	3e+12	3e+12	3e+12
	VTN	energy	25	25	25	25
	PPJAC	noise	3e+12	3e+12	3e+12	3e+12
	PPJAC	energy	200	200	200	200
✓	gas	un	0.073085	0.073085	0.073085	0.073085
✓	RLED	noise	7e+12	7e+12	7e+12	7e+12
	SCFIn	time	45	45	45	45
	SCFIn	temp	900	900	900	900
	SCFTr	time	30	30	30	30
	SCFTr	temp	900	900	900	900
✓	to	un	0.193849	0.193849	0.193849	0.193849
✓	Leban	un	0.492000	0.492000	0.492000	0.492000
✓	S_in	14Am	8.2828e-05	1.3449e-05	7.8497e-05	1.2320e-05
✓	vib	150	0.2532	0.2501	0.251	0.2544
✓	S_out	1mVdc	103.1	100.2	105.5	101.8

Run Table showing splits data.

## COMPREHENSIVE DATA MANAGEMENT

Once the simulation flow is graphically defined within the Taurus-WorkBench environment, Taurus-WorkBench automatically manages all data generated and records how each stage depends on data generated at earlier stages. When changes are made to any simulation module Taurus-WorkBench will automatically re-execute all later stages of the flow so that subsequent is current. In this way, Taurus-WorkBench removes the burden of simulation data management from the user and lets him focus on solving technology problems, not simulation details.

## INTERACTIVE POST-SIMULATION GRAPHICAL AND STATISTICAL DATA ANALYSIS

Taurus-WorkBench provides the engineer with easily accessible post-processing graphics using simple point-and-click operations. In this way, graphical analysis tools from Avant! and elsewhere can be used to generate plots ranging from device structure cross sections to parametric variation across multiple simulation splits. Additionally, the user can statistically analyze post-simulation data in a variety of ways. Providing capabilities that range from determining statistical variations in parametric measurements to doing complete correlation studies for identifying fault signatures, Taurus-WorkBench enables the engineer to extract critical information embedded in raw simulation data.



Visualizing results of a single wafer.

## SIMULATIONS ON A SINGLE COMPUTER OR ACROSS A NETWORK

Taurus-WorkBench provides the user the ability to either run all simulations on a single computer or have them executed on various remote systems on the network (i.e. job farming). This is done automatically with the user having the flexibility to limit execution of any tool to specific systems on the network. Taurus-WorkBench enables the engineer to fully use all the computer resources available and solve his technology problem in the shortest time possible.



Running an experiment.

## MAJOR FEATURES

- Hierarchical system with an intuitive graphical user interface.
- Encapsulation of simulations in Modules/Commands.
- Complete data management of simulated splits.
- Library management for storage of simulations and results.
- Parallel network execution of simulated splits.
- Built-in icon editor to create Module/Simulator Driver/Tool icons.
- Open architecture, capable of tightly integrating a variety of tools.

- Built-in design of experiments.
- Flexible post-processing with user-defined macros and tools.

## **SIMULATORS INTEGRATED WITH TAURUS-WORKBENCH**

- Process:
  - TSUPREM-4™.
  - Taurus-Lithography™.
  - Taurus-Topography™.
- Circuit Simulation:
  - Star-Hspice® and other SPICE-based circuit simulators of parameters and data to be used within individual optimization steps.
- Device:
  - Medici™.
  - Davinci™.
- Technology Characterization:
  - Raphael™.
  - Aurora™.
- Third-Party Tools:
  - Easily added through open interface

## **STATISTICAL ANALYSIS, DESIGN CAPABILITIES AND GRAPHICS**

- Extensive Design of Experiments capabilities, including:
  - 21 standard DOE methods.
  - Custom design using user-provided data.
- Comprehensive statistics, including mean, sigma, variance, error, derivation, skewness, kurtosis, Cpk, correlation matrix and principal components.
- Response surface modeling capabilities with polynomials, rational models, transformation sampling etc.
- RSM visualization: contour plot, constrained design space.
- Optimization of design.
- Taurus-Visual interface.
- Third party tools, such as BBN RS/1 or BBN
- Cornerstone or others, can be easily added through open interface.
- Histograms and scatter plots.

## **SYSTEM REQUIREMENTS**

- Platforms:
  - Taurus-WorkBench operates on UNIX workstations from DEC, Hewlett-Packard, and Sun Microsystems.
- Memory:
  - 16 Mbytes.
- Disk Space:
  - 23 Mbytes for executable. Additional disk space is required for simulation data storage based on integrated tool set and application.