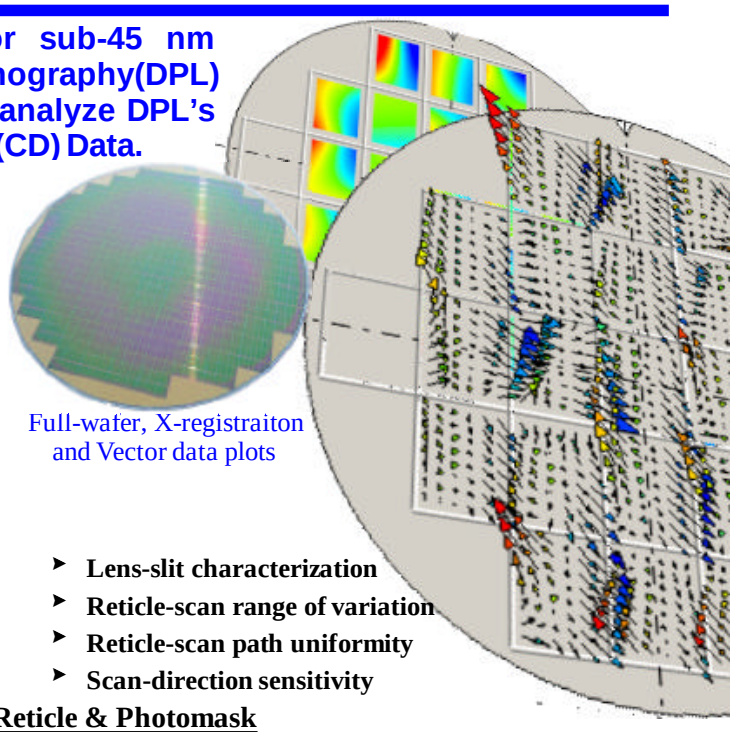
Product Overview

TEA Systems Corporation

Vector Raptor

Advanced Overlay & Registration Control

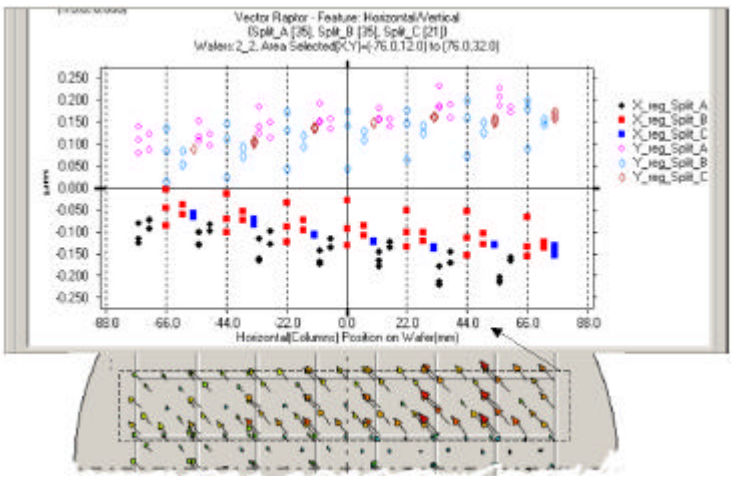
A 7th generation overlay & registration tool for sub-45 nm Lithography. Includes special Double-Patterning Lithography(DPL) tools such as the ability to comparatively model & analyze DPL's influence on any feature profile or Critical Dimension (CD) Data.



Full-wafer, X-registraiton and Vector data plots

Applications

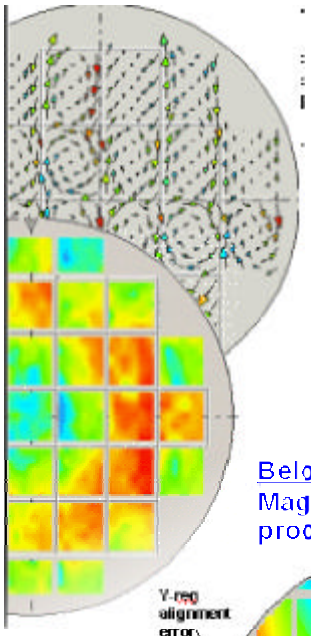
- **Engineer'sWorkbench or ProductionAutomation**
  - Analyses can be encapsulated intomacros and production automated with trend charts usingWeir DMA
- **Eliminate Double Patterning (DP) Error Sources**
  - Reticle
    - Process error effects on Enhance Feature response
    - Scanne- to-pattern alignment
    - Registration mark-to-pattern alignment
    - Haze and lens contamination buildup
    - Individual Site Errors
    - Pattern registration drift
    - Target quality assessment
  - Process
    - Film Thickness nonuniformities
    - Edge and edge-bead influence
    - CD size vs Registration Correlation
  - Metrology Tool
    - Hard metrology errors
    - "Soft" errors from "near-miss" captures or process
    - Precision and covariance of variables
  - Exposure Tool
    - Wafer leveling and edge effects
    - Substrate film sensitivity
    - Grid stepping
    - IntraField and InterField variation
    - Lens-slit characterization
    - Reticle-scan range of variation
    - Reticle-scan path uniformity
    - Scan-direction sensitivity
- **Reticle & Photomask**
  - Process Control and control-surface mapping
  - Data encapsulation for reticle signature transmis-sion to the wafer fab
  - New design qualification Process uniformity con-trol
  - In-wafer-process reticle validation
- **Simulation Support**
  - Results feedback and verification
  - Process tolerance derivation for Design for Manu-facture
  - Lot, wafer, reticle, field, lens and scan signatures
  - Feature response confirmation
- **Characterization & Optimization**
  - Double Patterning Lithography (DPL) control
  - Double Exposure Lithography
  - Focus & dose signature response mapping for RET
  - Reticle stage-direction sensitivity m apping
    Reticle feature derivation from wafers images
  - Lens and scan-stage performance modeling
  - Matching of tool sets & reticles
  - Exposure tool stage, wafer-leveling, scan direction, lens slit performance on profiles, Pre-lot exposure setup
  - Reticle and wafer signature removal for improved tool and process-contribution characterization



Mouse-selected data subset plotted as a function of X-location on the wafer

TEA Systems

65 Schlossburg St.
Alburtis, PA 18011
TEL: (01) 610 - 682 - 4146
Email: Info@TEAsystems.com



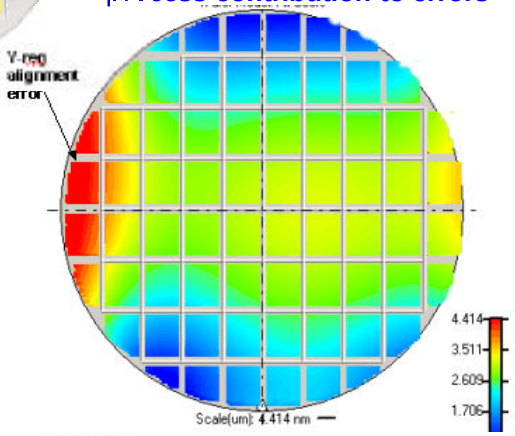
Left Top: Field Rotation coefficient response showing both full-field rotation errors and Scan-Slit rotation.

Bottom: BARC Uniformity contour plot.

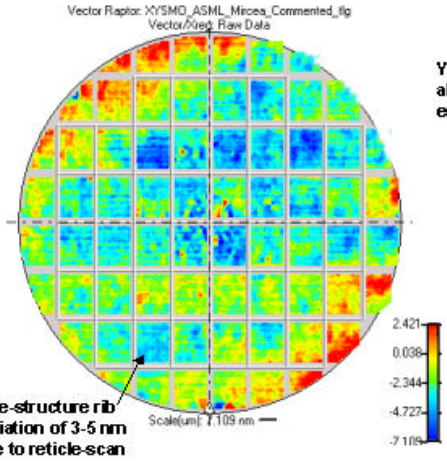
Applications Continued

- **Film-control and feature design**
  - automated error-budget and precision calculation.
  - spatial characterization.
  - wafer, field, lens-slit, reticle-scan and mask-feature/site perturbation analyses.
  - model and simulations for "what-if" scenario queries during tool tuning sequence.
  - 2D and 3D control surface mapping.
  - optional removal of selected modeled, raw and reticle errors before analysis.
- **Exposure Tool and Metrology**
  - characterization and critical setup
  - Error-budget and precisionmodule.
  - performance and variable covariance mapping.
- **Yield Control**
  - APCModeling Engine using Weir DMA scripting
  - Reticle performance evaluation
  - Reticle Enhancement Technique (RET) optimization
  - Simulation of full-process contribution and corrections
  - Exposure; source and uniformity mapping
  - Film uniformity mapping Performance and process daily monitor

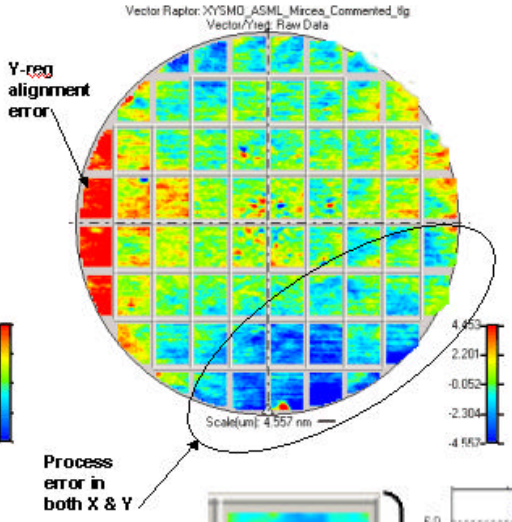
Below: X-Y Overlay Vector Magnitude Contour plot showing process-contribution to errors



Xreg data



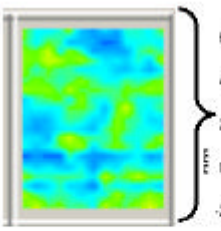
Yreg data



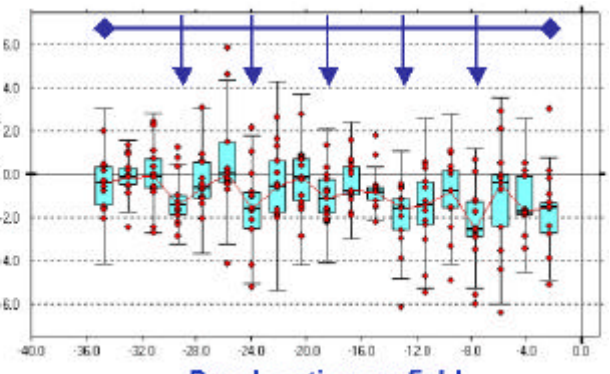
Left: X & Y Overlay Contour plots showing wafer-edge errors of process. Notice the larger errors located in the very center of the wafer from the photoresist dispense step.

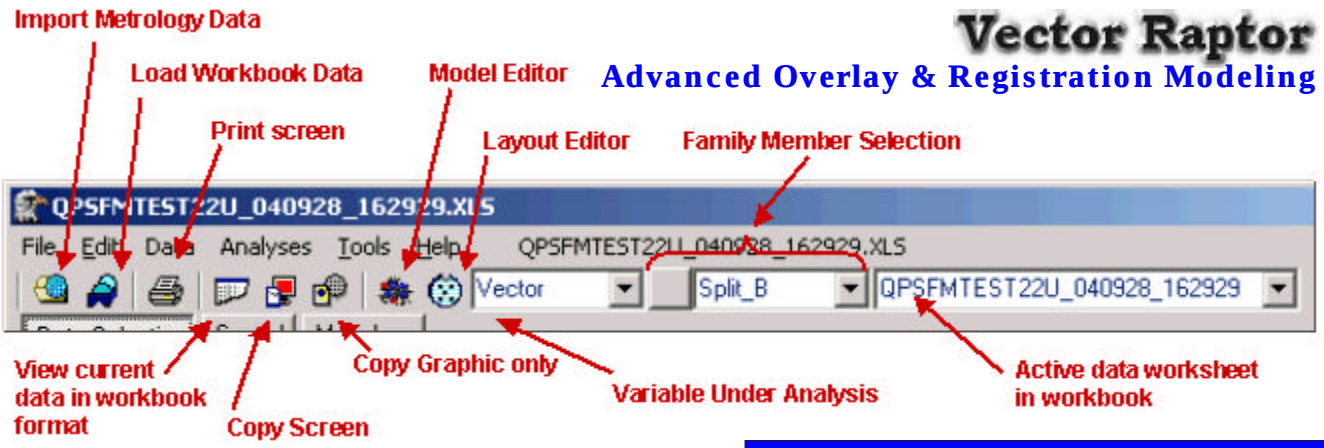
Also notice the four dice on the left edge where the Y-alignment failed.

Right: Single contour field of X-Overlay errors exhibiting reticle-scan induced errors.
Box-Plot to right charts X-Overlay as a function of the Row Position on the field. Notice the ~5 nm cyclical error caused by the reticle-scan.



Note 5 mm scan-cycle of X-Overlay



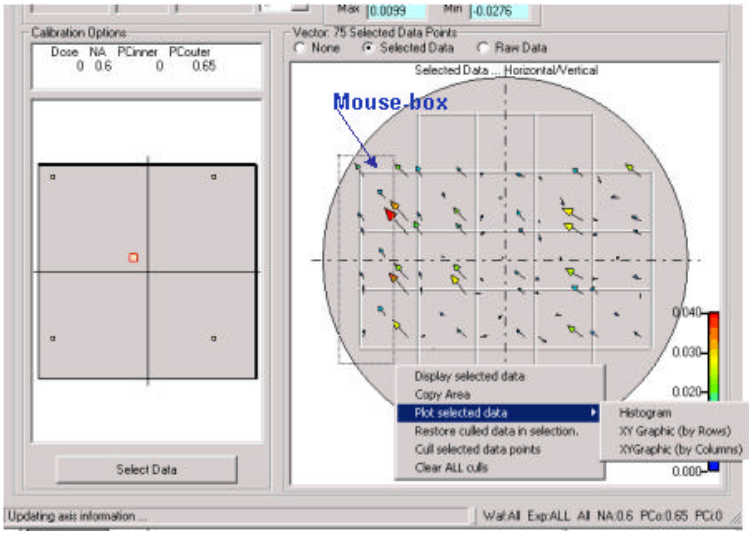


Data Input & Storage

- Vector Raptor loads data from the ***Weir Standard Format*** storage that uses Microsoft Excel © workbooks. After the first raw-data import, this workbook is retained and loaded directly into the software from this user-friendly format. All data, analysis reports and Vector-Raptor derived response data sets are always available and open to the user.
- Weir Workbook entered data and reports are summarized in a hyper-linked "Index" for rapid access and can be saved to any html-format site.
- Data from ANY metrology tool is easily imported into the Weir Workbook for analysis.
- There is never a charge for updates or additions to the metrology library as long as the data is a standard metrology format or is intensively used by the customer.
- ASML overlay, registration and FOCAL data too !
- Drag & drop file loading.
- Open, documented data and report formats

Storage & Reporting

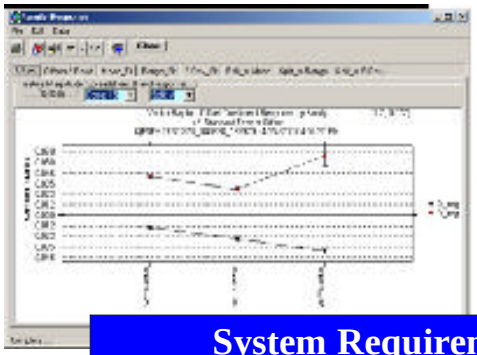
- Microsoft Excel ™ Spreadsheets and workbooks
- HTMLReports; many reports are generated and stored in the data's Weir Workbook. Reports and graphics can be saved into HTML format for display on any web site.
- Open system; access to all raw, calculated and modeled data.



Box in any data subset to cull points, plot graphics or view data points

Features

- Models
  - User-customized & industry-standard
  - Advanced adaptive control surface engine
  - Automated singularity and spread culling
  - "What-if" simulation performance analysis
  - Application to grid v. wafer performance
  - Process, InterField, IntraField, Lens-Slit & Reticle Scan focus application
  - Process, grid, lens and slit/scan extraction
  - Registration vs Critical Dimension comparison
- Graphic & Data Interface
  - Drill-down, interactive graphics and data
  - Mouse-generated graphics, viewing and culling of any data subset
- Five (5) levels of manual & automated data culling
- Any size data set up to 65,536 data points
- Supporting Analyses
  - Precision calculation
  - Covariance calculation
  - Radial wafer dependency analysis
  - Feature population frequency and spectrum



Coefficient response & uncertainty by mark-desig family for double patterning

System Requirements

- Vector Raptor is functional using single-node and multi-node licenses on Windows 2000 and XP.
- Microsoft Excel is required for data storage.
- Pentium IV CPU, 1.2 GHz, 256 Meg of RAM, 1024x768Graphic Monitor and 2.0 G bytes free space on disk for programs. Data storage may require up to 8.0 Gigabytes additional.

http://www.TEAsystems.com - Contact TEA Systems Corp. (+1) 610-682 4146 or WeirEngr@TEAsystems.com

A New Approach

Overlay and registration data analysis has been used extensively since the early 1980's when automated metrology was first introduced. There have been many overlay software packages provided over the years and every metrology tool and some exposure tools come with their own software. So why a new software package for overlay and registration analysis?

Quite recently classic overlay metrology methods based on automated optical microscopes have been joined by ellipsometer and scattering techniques that simultaneously measure both overlay and feature profile characteristics. Process control efforts therefore need a device-independent means of reading in data from any source to calibrate and understand the metrology response to subtle changes in test pattern design. New methods of comparison, correlation and calibration are also needed to tune these tools for process yield control.

Recent device-design nodes enjoyed the presence of process margins that had been improved to the point that most of the overlay error was within the capabilities of a properly tuned exposure tool ("Scanner"). However *this safety margin was eliminated* as recent radical changes in the approach to semiconductor manufacturing lithography were altered by a drastic change in direction of the technology roadmap into "Double Patterning".

"Double Patterning" (DP) is the selected method of extending the current proven "i193" technology to smaller feature sizes by splitting the most complex layers of new designs into two to five imaging levels. Each split level requires sequential exposure anddevelopment of different resist films and multiple etch steps to transfer the pattern-mask into the substrate. The intent of this technique is to allow the level of reticle enhancement to remain at present levels while continuing chip-design progress a few more nanometers (nm) down the design-node slope. Classic overlay control techniques have been developed to optimize layer-to-layer pattern registration. Reticle manufacturing problems such as alignment-mark to device-pattern registration were easily controlled as a simple offset and rotation of the wafer exposure. Reticle-manufacturing process variations were acceptable as long as the feature size distribution feel within production tolerance. These levels of control are no longersufficient for the needs of sub-45 nm designs.

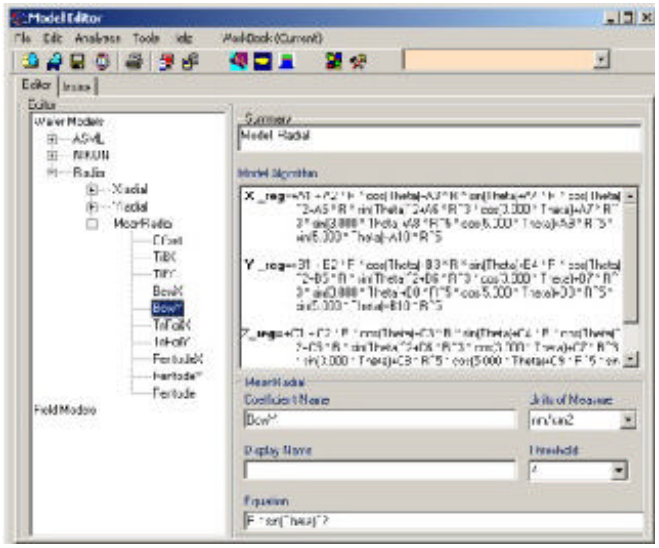
The complexity of Double Patterning technology is raised by **increased within-layer pattern-to-pattern registration demands** to the mask-maker as well as the device manufacturer. The DPmethodology presents a need for some very clever pattern-splitting algorithms in chip design to minimize the number of exposures required to piece together these critical layers. For the lithographer, these splits mean that the demands on process control will spiral upward with the additional need to control multiple reticle pattern shifts, rotation and even the effective critical feature size that are now occurring within a single lithographic device layer andwill eventually still be subject to the same intra-layer requirements. For the first time the overlay and even feature size uniformity of the most critical layers of the process will be registration and feature-size sensitive to whole-wafer process and exposure tool systematic drift whose errors are now derived from both reticle and wafer fabrication steps. Small changes in reticle alignment mark to pattern placement result not only in single-field registration errors but also in a reduction in feature size uniformity. Small variations in across-plate reticle process uniformity from etch or film variation compound to increase the across-field and across wafer uniformity of critical features and single-layer registration that in-turn complicates the overlay task of alignment to it's referencelayer.

So with a device-layer now exposed by two to five reticles, how does the lithographer quantify and correct for errors created by the individual mask, wafer-process or exposure tool?

Vector Raptor provides the tools needed to extract the individual contributions of metrology, reticle, process and exposure tool. These new tools are enhanced by:

- Tools for **Double Patterning Lithography (DPL)**
  - Breakout for comparison all raw data values and modeled control-surface elements by DPL pattern-split, wafer, focus, dose, NA, Sigma, scan direction etc.
  - Apply any models to wafer, field, scan-direction or lens-slit to determine the level of error contribution of each
  - Deconvolve the source of pattern misregistration to reticle design, reticle process, metrology, wafer process, scanner-stage, scanner alignment, scan direction, lens error or old-fashioned alignment error.
  - Load and compareANY critical dimension (CD) or feature/film profile data to overlay or registration data to determine the level of Double Patterning error's contribution to feature-size errors.

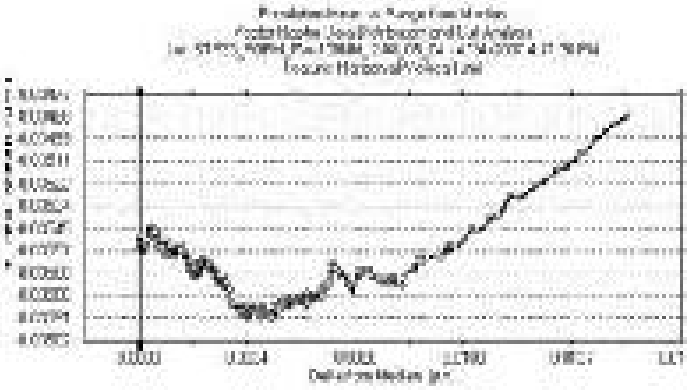
VR Model Editor



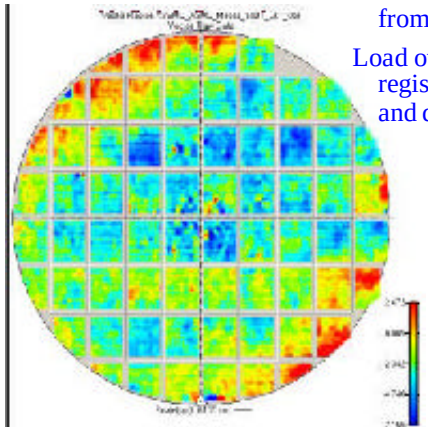
  - Advances in **modelingmethods**
  - improve precision and accuracy,
  - industry-standard models are provided for all exposure tools
  - user-defined models with the unique VR Model Editor
  - model application to derive scanner stepping-grid or process induced errors.
  - model fitting to fulfill the classic full-field alignment requirements as well as reticle-scan and lens slit contributions
  - highly advanced tools that enable the lithography to model the above sensitivities to variations in exposure-dose and defocus.
- an **object-oriented approach** to data organization
  - allows drill-down examination of graphics with direct linkage to the data,
- automated **precision** analysis
  - extracts performance issues between metrology, reticle and

http://www.TEAsystems.com - Contact TEA Systems Corp. (+1) 610-682 4146 or WeirEngr@TEAsystems.com

Graphics



Feature Response from Population Median used when testing metrology fidelity

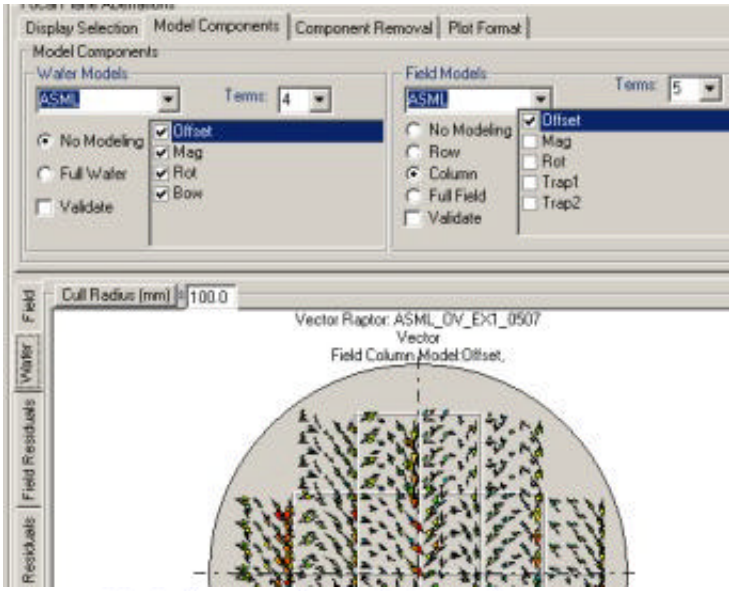


X-Axis Registration data fromASML Metrology.

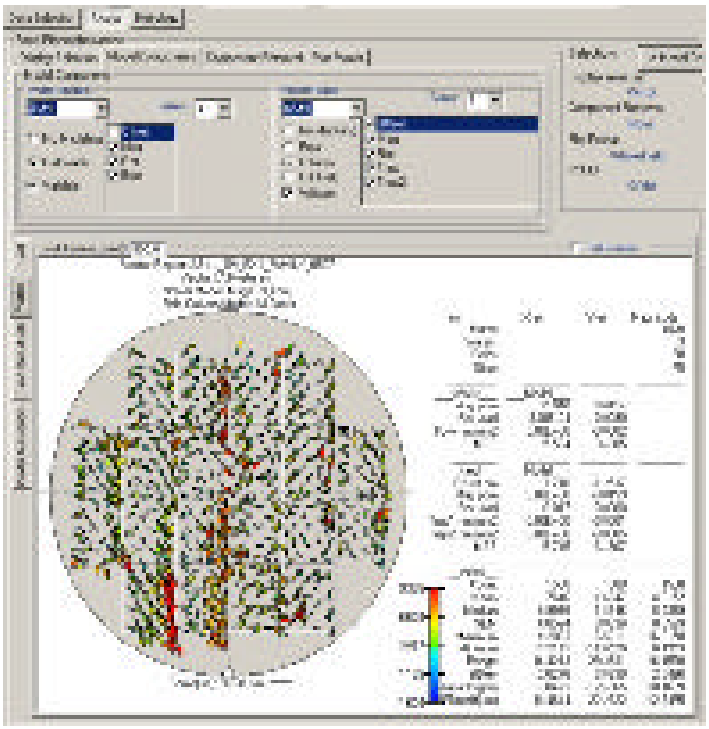
Load overlay, two-layer registration, excluded and derived data.

exposure-tool contributed errors such as stage-stepping, reticle travel, scan-direction and lens-slit aberrations

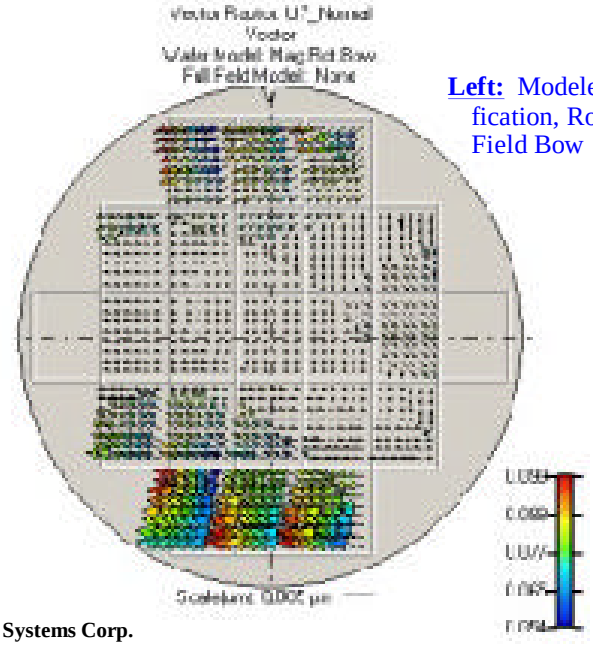
- **simulation** of individual error-source contribution
- **correction improvement** based upon measured and modeled performance.
- **automated correlation** between metrology variable response and feature-design
- **data culling** supported by multiple levels of interactive and automated techniques to improve calculation precision
- easy incorporation of **focus and exposure-dose response** through the use of the interactive graphic interface, a library of user-defined layout templates or direct data acquisition from the metrology (when provided).



Model selection controls, application and term-display for "What-if" scenario simulation



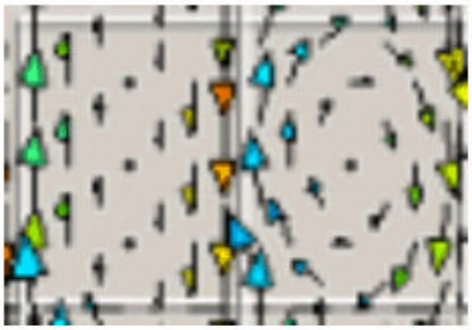
Wafer & Field Modeled Corrections

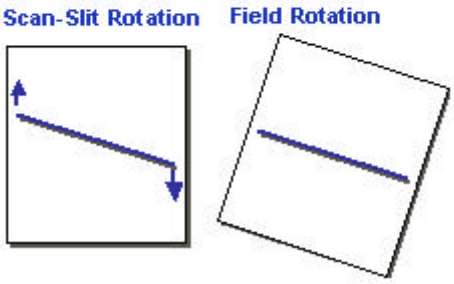


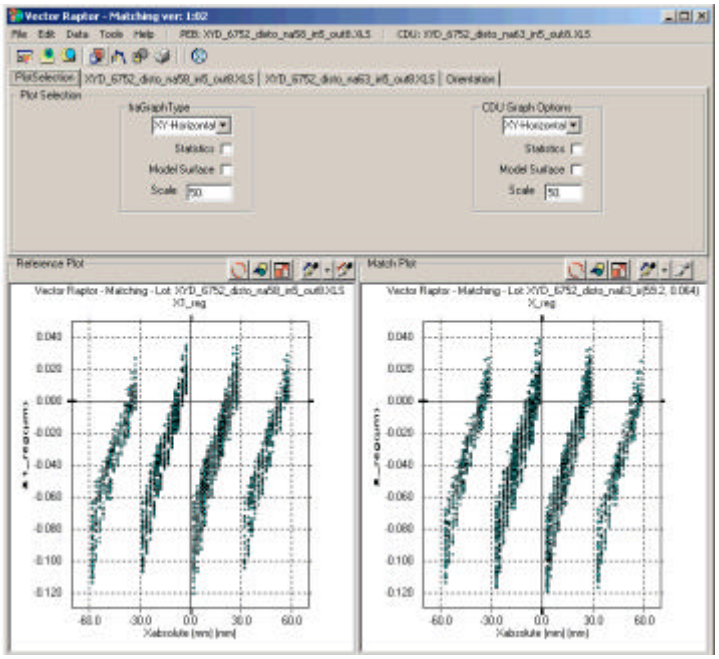
Left: Modeled Magnification, Rotation and Field Bow

http://www.TEAsystems.com - Contact TEA Systems Corp. (+1) 610-682 4146 or WeirEngr@TEAsystems.com

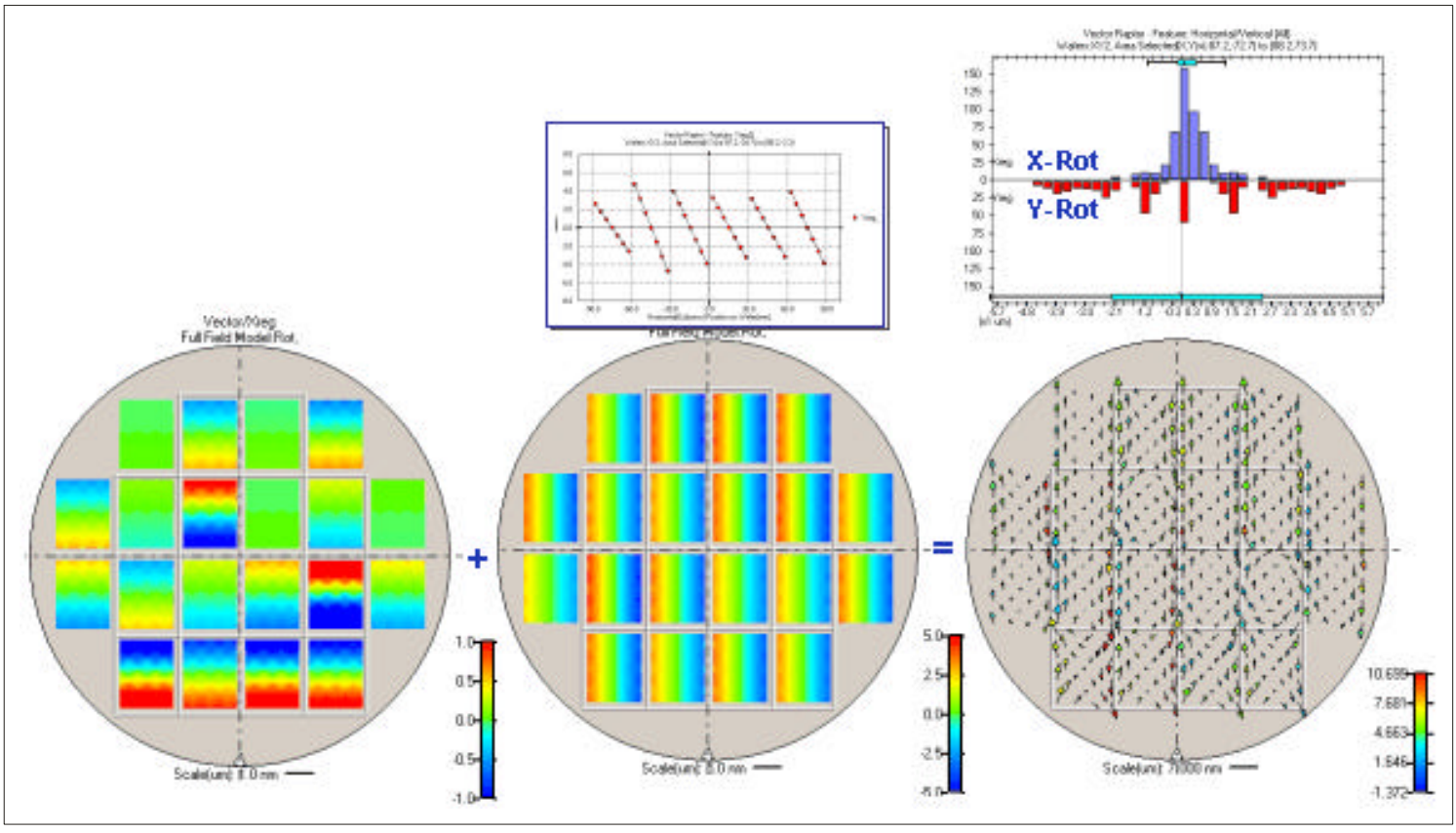
Graphics







Top: VR MATCHING Interface



Top: Field and Slit rotation Analysis

http://www.TEAsystems.com - Contact TEA Systems Corp. (+1) 610-682 4146 or WeirEngr@TEAsystems.com