Challenges
Increased manufacturing complexity in today's semiconductor, display, c-Si solar and LED factories requires better control of advanced processes. Manufacturing processes may be disrupted due to a variety of factors such as wear and tear on equipment, process drifts, inconsistent operation, maintenance events and product changes. Process disruptions can result in lots that are out-of-spec and off target. For example, pad wear in a chemical mechanical polish process that results in wafer thickness variances may require recipe adjustments by engineers to ensure proper process targeting. Other variances due to tool age, if not corrected, may also lead to scrapped wafers.

Controlling disruptions is essential as factories invest more in automated information handling, equipment integration and advanced process control (APC) tools such as R2R controllers that monitor and control process variations. However, one manufacturing challenge is that many of these systems are decentralized without a unified platform, a shared data repository or common algorithms. Because many of these systems are also homegrown or highly customized, heavy IT involvement is required when new manufacturing lines are added, leading to a high cost of ownership.

Solution Description
The Applied E3 R2R control module is the only R2R system built on a common platform with integration to statistical process control (SPC), fault detection and classification (FDC), equipment performance tracking (EPT) and advanced data mining (ADM) systems. The module gives process engineers the ability to automatically make adjustments to a process in order to maintain specific properties of the product (for example, wafer thickness or critical dimension) at a required target value. It uses metrology data taken at each process step to adjust process recipes on a run-to-run basis. In addition, integrating with FDC and SPC allows the controller business rules to accommodate process and material excursions seamlessly.

AUTOMATIC RECIPE TUNING. The R2R control module improves processing performance and reduces process variability by optimizing recipe parameters from lot-to-lot or wafer-to-wafer based on feedback from process models, incoming variations and metrology data. Available at the tool or chamber level, R2R allows customized strategies to be performed in a highly automated fashion. R2R enables lower cost of ownership (CoO) by reducing model management activities through a unified modeling structure approach and advanced patented technology. This technology supports high mix, high complexity manufacturing operations and accommodates missing and out-of-order metrology data.

PRECONFIGURED MODELS. The module includes preconfigured R2R models for critical process areas that significantly reduce deployment time, enabling faster results for engineers. Areas that can benefit the most from R2R include lithography, etch, deposition, chemical mechanical planarization (CMP) and diffusion in semiconductor manufacturing; lithography, chemical vapor deposition (CVD), physical vapor deposition (PVD) and implant in display manufacturing; and in the overlay process in solar manufacturing.

E3 R2R improves processing performance and reduces process variability by optimizing process parameters from one run to the next. This example control chart shows a drifting process in furnace thickness uniformity that was corrected after making an adjustment.

**PROCESS PARAMETER OPTIMIZATION**
Customer Results

Historical data from E3 R2R implementations at customer sites have shown Cpk improvement on several tool types, as well as throughput improvements and reductions in process time, send-ahead wafers, scrapped wafers and downtime. The following table summarizes many of these performance improvements:

<table>
<thead>
<tr>
<th>Performance Area</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process capability (Cpk)</td>
<td>40% average improvement</td>
</tr>
<tr>
<td>Process accuracy</td>
<td>30–60% increase</td>
</tr>
<tr>
<td>Rework rate</td>
<td>From 3% to 0.8% reduction</td>
</tr>
<tr>
<td>Scrapped wafers</td>
<td>95% reduction</td>
</tr>
<tr>
<td>Process yield</td>
<td>0.35% increase</td>
</tr>
<tr>
<td>Process cost</td>
<td>$13M savings</td>
</tr>
</tbody>
</table>

Package Contents

Designed around best known R2R control methods for process optimization, the R2R module offers proven technology in one package, which includes:

**LICENSE AND PLATFORM**

> Applied E3 R2R module license
> Applied E3 platform with strategy engine, logic strategies, and designer and dashboard interfaces

**TRAINING AND SUPPORT SERVICES**

> User training and application consulting (optional)
> One year of maintenance and support

Server hardware and installation services sold separately.

**APPLIED MATERIALS EXPERTISE.** Applied Materials has the expertise and solution portfolio to help manufacturers maximize factory value with data capture and analysis, best known method integration and comprehensive reporting. With a deep knowledge base and a rich history of providing products and solutions specifically addressed to the semiconductor, display and solar industries, Applied Materials experts provide services to deliver turnkey solutions that offer quick value and short ROI.