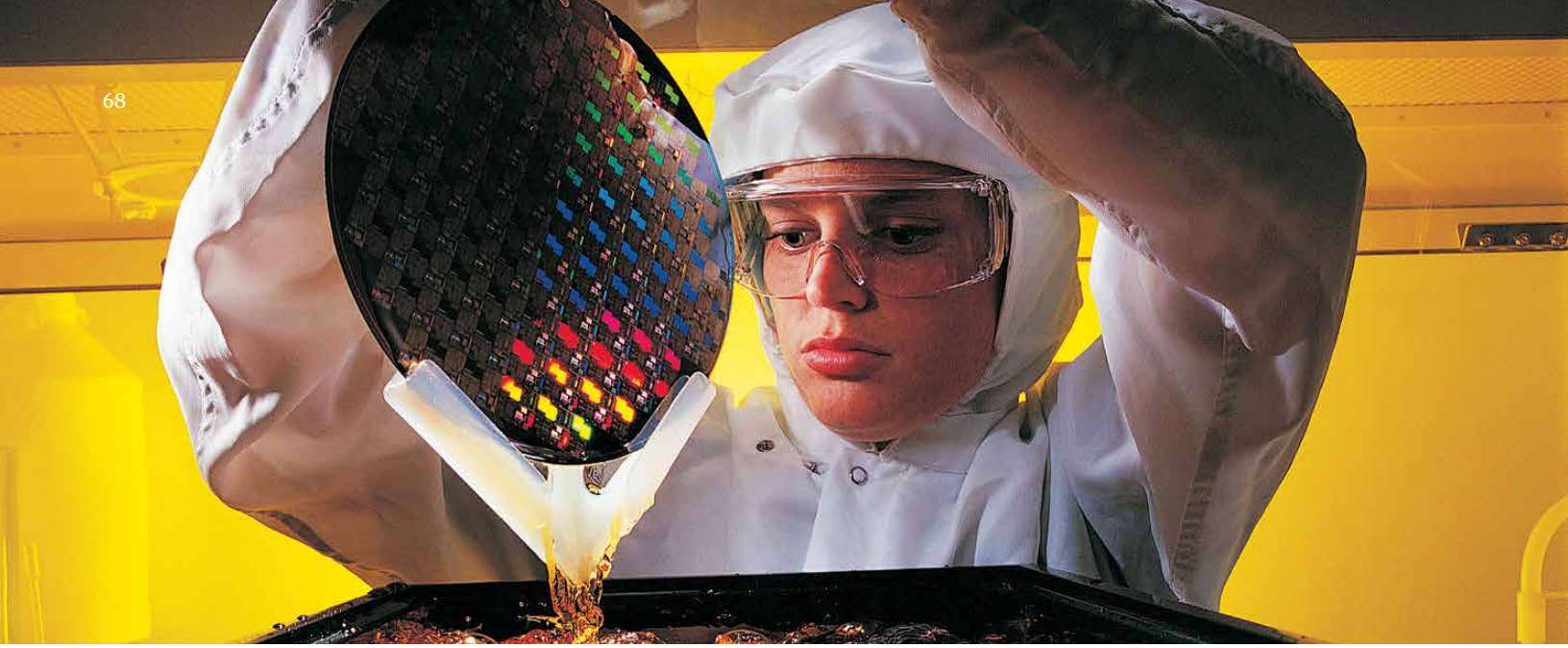

Fab diagnostics:
A data-driven approach to reining in the cost of indirect materials

Companies that use a set of core analytics to assess consumption patterns can gain better control of production expenses.

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Indirect materials—the substrates, chemicals, slurries, specialty gases, pads, films, spare parts, and other critical ingredients used to make integrated circuits—typically account for more than 30 percent of the cost of front-end semiconductor fabrication.[1] But fab managers have had a tough time getting a handle on these expenses, in part because of the limited control they have over materials pricing and because they are more likely to examine projects, supplies, and production activities in isolation rather than considering their impact across a fab's entire portfolio.

To deal with these and other cost issues, semiconductor executives should adopt an analytics-based approach to materials cost management. By systematically assessing the data the fab collects on processes and materials, managers can better understand spending by supplier and by fab. As a result, they can emphasize cost-management efforts that may have the greatest impact, and they can undertake discussions with suppliers more confidently.

In this article, we introduce several data-centric methods that managers and engineers can use to identify cost-saving opportunities and reset priorities. Based on our experiences, these tools can help managers achieve cost savings of more than 15 percent—far better than the single-digit average savings typical even in mature, 200-millimeter fabs. The tools can provide a straight-

forward, repeatable reading on the resource situation at any fab. But implementing them successfully requires support from all the departments that are using the respective chemicals or other materials. All have a vested interest in ensuring that the fab can reduce costs year after year to keep pace with the price erosion the industry is experiencing.

Savings stumbling blocks

Why don't more fabs achieve better results from their cost-management programs? There are two main factors.

A narrow view of consumption. Resource-management efforts have tended to be ad hoc, in part because of the relentless pace of product development and the number of nodes in play. In this climate, managers evaluate costs by project, and some waste is considered part and parcel of the production process. Additionally, the decentralization of production activities often leads to a lack of coordination among semiconductor-module teams, sales teams, procurement specialists, and other units within a fab. This can result in a poor understanding of the types of chemicals required and which suppliers to target. For example, in one company, a module-engineering team in the lithography department was trying to optimize the mix of ingredients necessary for a single resist (a thin layer of polymer used to transfer a circuit pattern to a semiconductor substrate), to minimize cost overruns. The team was unaware, however, that the number of products using this particular resist was expected to fall in the near future—and that focusing on this recipe would have little impact on costs.

Limited control over resource pricing. The typical semiconductor manufacturing process involves a wide variety of chemicals; a fab may stock and use more than 50 chemicals within the lithography stage alone. But there are only a handful of established chemicals suppliers, and plants are reluctant to switch to new ones given the long lead times required to qualify them—in some cases, it can take up to a year. As a result, incumbent suppliers are shielded from price pressures, and fab managers have less opportunity to explore potentially more advantageous relationships with existing or alternate vendors.

Applying the diagnostics

There are a number of analytic tools and techniques that engineering teams and semiconductor executives can use to better manage production resources, but we believe two are particularly effective for ensuring that no cost-containment measures are left on the table: the heat-map analysis and the mass-balance analysis. The former is a prioritization tool; it gives fab managers a high-level overview of the line items associated with semiconductor production, and it allows them to spot the gaps in their management of certain chemicals and other inputs. The latter offers a deep dive into the consumption patterns revealed by the heat-map analysis, giving fab managers the information they need to make smarter, more cost-effective resource and operations decisions. When combined with other methodologies—among them, spending analyses and time-to-failure and complexity assessments—heat-map and mass-balance assessments can provide the backbone for a strong, systematic cost-management program.

The heat-map analysis. The first step in any effort to reduce costs is to know which materials are in greatest demand or have seen the most significant changes in usage over a time period being considered. Heat maps are effective for creating this level of transparency. A module-engineering

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team can inventory and record all items used across the fab using the vast amount of routinely collected product and process data—albeit usually in uncoordinated fashion. With input from procurement managers, the team can then categorize and rate indirect materials and maintenance items along several dimensions relating to consumption and pricing. In this way, the team can spot meaningful gaps in their cost-control programs.

At one large fab, for instance, managers assumed they had created a comprehensive program for reducing their consumption of indirect materials, simply because of the breadth of their efforts: there were more than 100 cost-cutting initiatives going on throughout the company, most of them focused on optimizing existing product mixes. This is justifiably a common focus; we have seen many cases in which too much of an expensive chemical is incorrectly prescribed for a production process. But fab managers had not fully explored other cost-cutting opportunities focused on different cost-containment parameters—for instance, emphasizing waste reduction and considering the possibility of reducing the amount of certain chemicals used in setup and rework activities (process steps that happen in support of core chip development). By undertaking the mapping exercise, fab managers saw the gaps in their approach and inconsistencies across sites; different fabs were using different amounts of chemicals, even for the same tech nodes. Through their analysis, they were able to reprioritize their cost-cutting initiatives and, for some chemicals, the fab was able to realize savings of up to 50 percent.

The mass-balance analysis. This tool enables fab managers to drill down into the findings presented by the heat map and further delineate chemicals consumption. The goal is to create a snapshot of actual consumption patterns associated with particular ingredients compared with projected usage. Using these data, module-engineering teams and procurement managers can examine individual causes of waste.

The results of this analysis can be eye opening. One company's mass-balance analysis revealed a flawed batching process. The chemicals bath the company employed during the clean-tech stage

could accommodate up to 100 wafers at a time. Through the mass-balance assessment, however, the company recognized it was processing many fewer than that, wasting up to 40 percent of materials used in this step. Fab managers conducted workshops to generate ideas and determine how to address the challenge. By altering its batching steps and tool configurations, the company was able to improve its load factor, reduce waste, and cut costs.

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There will be inevitable roadblocks to implementation: resistance to change from module engineers, a shortage of time and talent within the modules to carry out new projects, and insufficient management capacity to lead the qualification process when adding suppliers. The fabs that adopt this approach may also require new technology systems for collecting data, as well as analysts and engineers who can perform regressions and other forms of data mining. They may also need to bolster capabilities in portfolio management; the analytical approach we are suggesting may turn up more cost-containment projects than fabs will have the time and resources to execute, and managers will need to focus on the projects with the biggest impact.

We cannot understate these challenges, but they should not stop fab managers from exploring analytics-based cost-reduction programs. Even small reductions and improvements will help put fabs in a better long-term cost and operations position.

[1] Front-end fabrication refers to the process of forming transistors directly in the silicon wafer.

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