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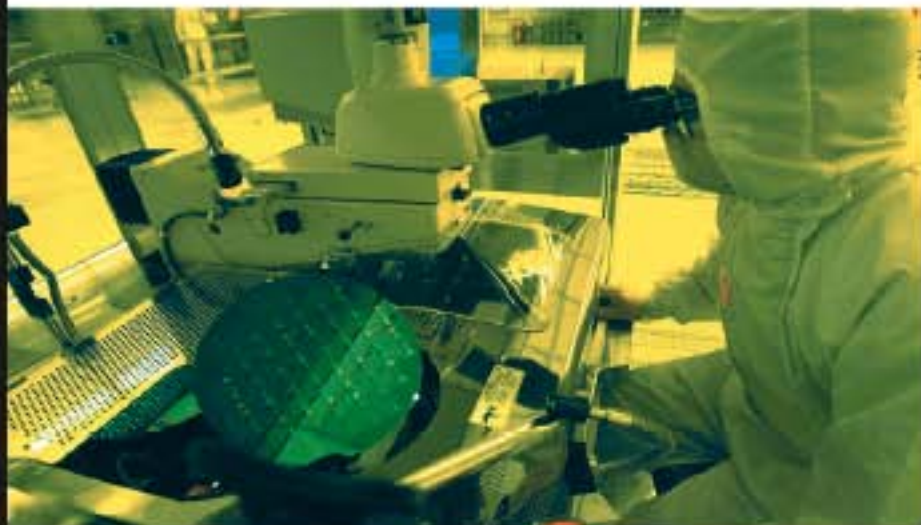
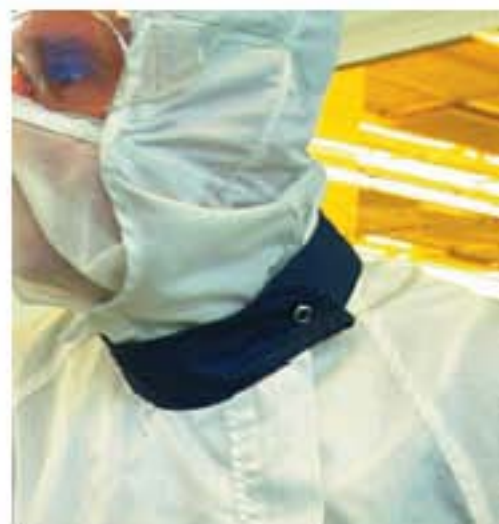
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European semiconductor



Time is right for mature process

International Rectifier discuss modern usage of bare die



RFID packaging at low cost
Getting below the nickel tag

Lead free responsibility
Ignorance will be no excuse

Powering to better yields

With every fractional change in a fab, yields are affected. A Fab Manager's day can easily be taken up in attempts to ensure a tool operates within the parameters required to enable the highest of yields. Effective Cost of Ownership (CoO) is an expectation from fabs today. **Bruce Fries**, Director of DC Systems at **Advanced Energy Industries** argues that awareness of CoO will always reveal the best from competing options.

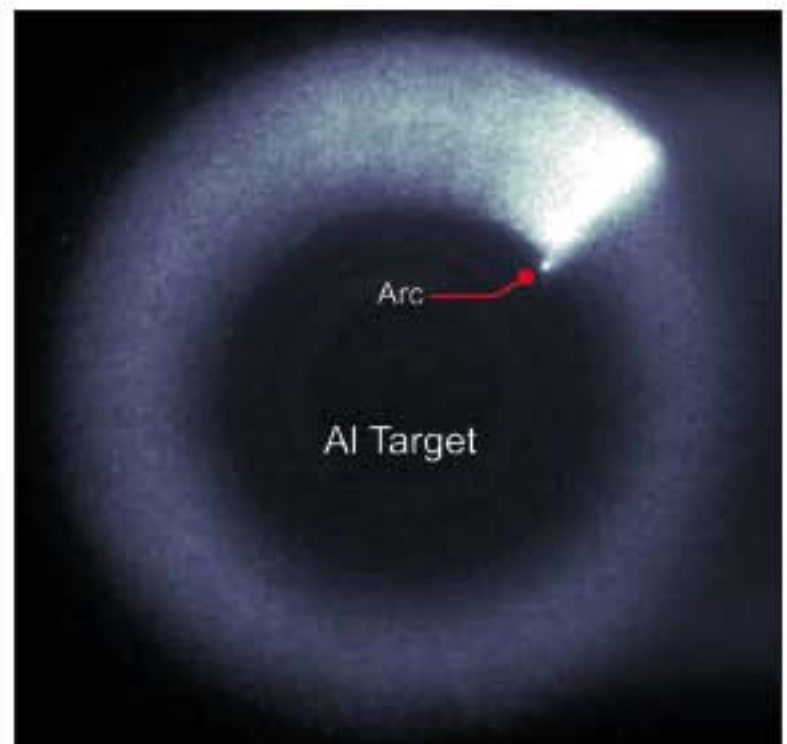
So, your company has decided to build the ultimate sputtering machine. Your task on the design team is to choose the vendor-supplied subsystems that will enable your team to build the best machine on the market. It should be an easy task—just choose the most advanced subsystems and you're on your way to success. But wait, there's a small problem: cost vs. performance.

Your fab customers, especially those who are using the most advanced processes to deliver leading-edge products certainly want the most advanced technology, but at the same time, they have to operate within their fab budgets. While your customers may be very impressed with your leading-edge equipment, what is it going to cost them?

There are plenty of companies out there who attempt to seduce the market with a variety of very convincing pretenses. Doubtless you've heard them all before: "Our products offer a comparable performance for a much lower cost." "With the use of extensive modeling and careful process management, our system won't fail to deliver as required." "We can provide exactly the benefits you need, without unnecessary bells and whistles, and for a much lower cost." They undersell you on price, while promising equivalent performance. Once they've beaten you on the sale and their tools are installed, they've made their profit and probably shut you out with that customer for that product generation.

What your customers want are the latest processes, geared for ever smaller geometries, in less time. At the same time, they want tools that have faster throughput, higher yields, greater reliability and lower operating costs for a low total CoO. They also want them with built-in expandability and capable of handling a wider range of processes. Oh yes, and they always want to pay the lowest price possible.

The situation is complicated by today's economic environment in which process tool makers are faced with shrinking R&D budgets, making it even more challenging to keep pace with technological demands. With steadily shrinking design cycles, it is increasingly critical to be able to quickly move new process tools from the lab and into a production environment.



An arc in process

How then, are you going to quickly develop that ultimate sputtering tool that delivers the latest in leading-edge process technology, without pricing your system out of the market? One way, is by delivering superior performance coupled with the lowest possible CoO. Getting your customers to focus on CoO rather than just price, allows you to compete with those "low-cost" competitors on more than just the price of the tool. It changes the competitive playing field, by forcing your competition to show how their tool will help enhance fab profitability.

How can you leverage CoO in designing new process tools? By challenging your vendors to deliver critical subsystems that enhance the performance of your tools, while reducing their

overall CoO. For example, a new generation of advanced DC power delivery systems capable of providing a "global" range of power for plasma-based process tools, offers equipment manufacturers opportunities to reduce system CoO by reducing system and operating costs, increasing yields and improving reliability.

To deliver on the promise of global power, a new generation of advanced DC power systems needs to provide an unprecedented level of fast arc handling to maximize yields with the multi-process flexibility of delivering full power across a wide 300 to 1300 VDC voltage range, thereby providing very high current for low impedance processes. Seamless installation with the varying voltage inputs found in North America, Europe and the Asia-Pacific region eases integration concerns, and with a power factor greater than 0.94, an operational efficiency of greater than 90 percent, and a design capable of storing input energy (required to ensure a reliable power source in case of "brown outs"), advanced DC power delivery systems contribute positively to fab management. Finally, possession of flexible communication protocols allows easy transition from the lab to production environments.

Advanced DC power supplies with the requisite voltage input and output ranges offer the process tool manufacturer a power delivery solution for all his plasma-based tools, regardless of process requirements or the global region for which they are intended. In doing so, they enable tool manufacturers to simplify system design by eliminating the requirement for separate power supplies for systems intended for different geographical regions. This, in turn, allows them to reduce their component inventories. Simplifying design and reducing component inventories both reduce system costs, thereby helping increase a tool manufacturer's competitive advantage two ways. First, by enabling a reduction in the price of its process tools and second, by delivering considerable advantages to the customer purchasing the tools.



Photo of a substrate showing meteor defects caused by arcing

Fab Benefits

Fabs that purchase tools using these new-generation DC power delivery systems will gain considerable benefits in terms of reduced total CoO for the tool due to simplified material management, reduced operating costs, increased yields and improved reliability.

Simplified Materials Management: Materials management is simplified in a couple of ways. Increased process flexibility can reduce the number of different types of process tools required in a fab, thereby simplifying spares procurement and inventory management. The fab also ends up needing fewer types of power supplies. In addition, this greater process flexibility translates into increased fab efficiency since it allows the fab manager to more easily switch manufacturing focus as required by market pressures to maximize profitability.

Reduced Operating Costs: The high power factor and power efficiencies delivered by this new generation of DC power supplies further help to increase profitability by reducing tool operating costs. As most fab managers know all too well, power companies tend to add expensive surcharges when a fab induces power factors much below 0.90. In some cases, previous generation power supplies offered power factors as low as 0.70, 25 percent less than the 0.94 power factor available from new-generation power systems. A greater than 0.94 power factor offers considerable savings when the time comes to pay a fab's utility bills—a savings that can help increase overall profitability.

Higher power utilization efficiencies—greater than 90 percent with the new-generation power supplies—help to further reduce operating costs by reducing the amount of "waste" power that must be dissipated as heat through fab cooling systems. Lowering the demand on the cooling system again translates into a lower utility bill. In addition, with their higher efficiencies, these new DC power supplies can be air, rather than water, cooled. This, in turn, simplifies system installation, further lowering operating costs by reducing the need for water circulation and purification systems in the fab. Eliminating the need for water cooling can also help free up valuable fab real estate.

Increasing power factor and efficiency also allows a fab to utilize smaller gauged cabling and smaller breakers and switches. When you consider the miles of cabling and the hundreds of breakers and switches used in a fab, the potential savings becomes very clear.

Increased Yields: New-generation DC power delivery systems help increase yields by delivering a higher level of run-to-run uniformity by delivering superior arc management, improved power stability, as well as very precise and repeatable TURN-ON/TURN-OFF process timing.

Discharging the Arc

Arcing, of course, is the single largest factor to consider when discussing yield-reducing process damage. An arc is a high current-density discharge that can occur during the powered plasma process. It is characterized by thermionic emissions on the surface of the electrode, substrate or chamber walls that reach sufficiently high temperatures to thermally liberate

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electrons. Typically, arcs last between a fraction of a microsecond to several milliseconds, although it is possible to create continuously burning arcs. This phenomenon often results in lost yields and can potentially damage the processing equipment. The new, advanced power supplies minimize the effects of arcing events across multiple processes by offering flexible arc management controls: for example, micro-arc shutdown times from 5 to 25 μ sec, hard-arc shutdown times from 30 μ sec to 40 msec, and arc detection threshold levels from 20 to 400 VDC. In addition, advanced power delivery systems can deliver as little as one-quarter the arc energy delivered by previous generation industry-standard power supplies (0.3 mJ/kW vs. 2 mJ/kW). These capabilities prevent substrate damage in the form of "meteors" on the film surface thereby enabling higher yields.

In addition, the most advanced of these new power supplies offer an optional configurable feature that helps to reduce arc damage, thereby further enabling higher yields. This feature enables synchronous arc handling in multiple-cathode systems, where a mosaic pattern of cathodes is used to provide power to the plasma. In such cases, there is a danger that an arc from one cathode could continue to draw energy from surrounding cathodes after the arcing cathode is shut down. When an arc occurs, this feature shuts down not just the offending cathode, but those surrounding it to prevent the arc from continuing to draw energy.

Enabling multiple target operation in a single chamber provides uniformity across large area substrates, while optimizing overall target costs. At the same time, these advanced DC power delivery systems offer a master/slave option configuration that allows the end user to run a single large target at significantly higher power levels if that offers superior performance for a particular process.

Run-to-run uniformity often relies on very precise and repeatable TURN-ON and TURN-OFF timing to control the metal sputtering process. Failure to carefully control this process due to the complex operating system's communication latency can result in non-linear deposition rates that can negatively impact yields. Since they are connected directly to the plasma, a power supply can minimize the latency issues that result when the system controller is used to control power delivery.

New-generation DC power supplies offer the capability to count down the actual energy (in watt-seconds or joules) that should be delivered to the chamber, accounting for such factors as arc events, power ramping algorithms and other process

variations. Once the countdown is completed, the power supply turns off the power on its own.

This "energy-delivered-countdown-timer"-known as joule mode-can be updated every 1 msec. The power delivery system remains aware of what happened the millisecond before, maintaining full accountability. As a result, each process run-given the accuracy of the measurement system-has exactly the same amount of delivered energy, resulting in highly uniform run-to-run deposition. This feature is of particular benefit to those processes intended to deposit extremely thin films.

Reliable manufacturing

In order to enhance reliability, companies delivering new generation DC power supplies have made significant investments in new analytical software and testing, as well as implementing accelerated life-testing and environment stress screening to raise the bar on field reliability. In addition, to reduce system downtime, the most advanced new-generation DC power delivery systems should incorporate a modular design that facilitates routine maintenance and minimizes downtime in the unlikely event of a power supply issue. Such modular designs, combined with proper training of fab maintenance personnel, would allow on-site fab workers to quickly change out modules as required, without depending on the arrival of the tool manufacturer's support personnel, to return a tool to operation. In general, it takes approximately 15 minutes to replace a new-generation power supply module, as opposed to the two hours it would likely require to replace an entire non-modular power supply.

Clearly then, the new generation of advanced DC power delivery systems offer the semiconductor-or any other industry with metal sputtering applications-considerable total cost of ownership benefits. They can accommodate any level or quality of power available in the world, providing the industry with the first class of truly "global" power supplies. Their wide range of power results in increased process-to-process flexibility.

In addition, the benefits offered by these power supplies increase system reliability, reduce fab and tool operating costs, and simplify materials maintenance. Perhaps most importantly, they improve run-to-run process uniformity and minimize defects for increased yields. Savvy process tool designers will want to leverage the benefits of this new class of power delivery systems to reduce the CoO and enhance the performance of their tools, thereby making them much more attractive offerings for their fab customers.