APPLICATION NOTE

The Art of Choosing the Right Power Supply

Introduction

Wise decision-making regarding process power helps you meet your particular goals for sputtering rate, film quality, and setup cost and complexity. Each power method offers a unique set of benefits and drawbacks. Therefore, there are no clear-cut answers. Your selection must be based on the recommendations presented here, as well as your individual process priorities.

Power Supply Selection Overview

Table 1 lists the primary factors involved in power supply selection, with ratings for each power method. Find the factors that are most important to your process in the leftmost column, and then choose the highest-rated power supply methods for these parameters. Consult the table further for information on your chosen methods' performance along all important criteria. Then, read on for more factors to take into consideration before making a final decision.

Table 1. Power supply selection matrix

Dielectric Type	DC	Pulsed DC	RF	Pulsed DC with RF	DC with RF
Sputtering Type	Magnetron only	Magnetron only	Magnetron or Diode	Magnetron only	Magnetron only
Appropriate Target Materials	Conductive only	Conductive only	All targets	Conductive only	Conductive only
Typical Sputtering Rate (% of DC)	100%	70 to 85%	20%[1]	70 to 90%	70 to 95%
Cost and Complexity	BEST	EXCELLENT	VERY GOOD	GOOD	GOOD
Campaign Length (Loss of Anode)	GOOD	VERY GOOD	EXCELLENT	BEST[2]	BEST[2]
Film Quality					
Optical Transmission	VERY GOOD	EXCELLENT	BEST	BEST	BEST
Flatness	VERY GOOD	EXCELLENT	BEST	BEST	BEST
Pinholes	VERY GOOD	EXCELLENT	BEST	BEST	BEST
Packing Density	VERY GOOD	EXCELLENT	BEST	BEST	BEST

[1] No magnetron

[2] No loss of anode even when using only one cathode

Process Setup Specifics

The following information addresses common issues in sputtering process setup. It resolves questions left unanswered by Table 1, on page 2, and offers power supply setup advice.

Choosing RF for Maximum Film Quality

If film quality is your one and only priority, RF power is the clear choice for process power. RF energy causes the electrons to become exceedingly energized in the plasma, creating a “hammer effect” in which the ions bring themselves down into the substrate with great force. This enables them to pack down tight to create very flat, uniform films, with low pinhole incidence.

The main drawback of RF power is its very low speed. Its sputtering rate is just 20%, while all other methods have rates of 70% or higher, up to 100%. However, for critical applications, such as antennae arrays and solar panels for use in outer space, this low speed may be tolerable. It depends on your priorities.

Setting Up RF

For processes using relatively small cathodes (1 to 1.5 m, 3.3 to 4.9'), matching network placement is key to correct RF setup. To maximize power transfer to the load, place the matching network as close to the cathode as possible. This decreases the length of the output cable from the matching network, which acts as part of the load. A shorter cable thus increases power transfer and process repeatability.

Grounding is another critical element in RF setup with small cathodes. The grounding strap must be wide to maximize surface area, as well as short. Also, all connections must be extremely clean to prevent resistance.

Unfortunately, there are no easy guidelines for processes using larger cathodes due to wavelength modes. Compared to small-cathode RF processes, setup is inherently more complicated and involves more trial and error.

Rotatable cathodes are not compatible with RF power, though recent developments in rotatable cathode technology may eventually allow for RF sputtering. At present, they generally are best used in DC or pulsed-DC powered processes, in which they can increase target utilization by 80 to 90%.

Choosing Between DC and Pulsed DC

Pulsed DC is almost always a better choice than straight DC because it enables better film quality and longer manufacturing campaigns. Most systems that are equipped with DC simply were set up before pulsing technology became available.

The addition of low-frequency pulsing makes for more energized electrons, enabling a "hammering-down" effect. This improves film flatness, packing density, and transmission, and reduces the occurrence of pinholes. Pulsed-DC-powered processes also require shorter, less-frequent chamber cleaning steps than straight DC. This dramatically increases process productivity and yield.

Cost is not a significant deciding factor between straight and pulsed DC. Pulsed DC enables the use of much less expensive target materials than straight DC. Please read further for details.

Saving on Target Cost by Choosing Pulsed DC Over Straight DC

In general, pulsed-DC power produces better film quality than straight-DC methods. This enables processes using pulsed DC to save on cost significantly by using lower-grade target materials. Any DC sputtering process will create "fingers" that can protrude into and through the adjacent layers. DC-powered processes, therefore, must use expensive, high-grade aluminum targets, while pulsed-DC processes can use much more affordable target materials, with no negative effects on film quality.

Choosing Between DC with RF and Pulsed DC with RF

Generally, pulsed DC with RF is a better choice than straight DC with RF. The same film quality, productivity, and cost considerations described in *Choosing Between DC and Pulsed DC* apply here.

Process Setup for DC with RF or Pulsed DC with RF

Combining RF with DC or RF with pulsed DC adds a certain amount of complexity and cost to process setup. Arc handling particularly presents a challenge when two different types of power are working simultaneously.

In these configurations, the DC or pulsed-DC power supply can more accurately identify and respond to arcs than the RF power supply. Therefore, your DC power supply must be able to control your RF unit to shut off both DC and RF power when an arc occurs. It must

also be able to quickly return power once the arc is extinguished. DC power supplies on the market today vary in this regard. While some offer no built-in DC/RF control method whatsoever, others offer powerful control. For example, Arc-Sync technology enables Ascent® DC power supplies to easily and effectively control a connected, Alta™ RF unit in order to handle arcs.

Choosing Between Diode and Magnetron Sputtering

Your priorities for sputtering speed, film quality, and target utilization determine the best choice between diode and magnetron sputtering. Diode sputtering applications produce better film uniformity, as well as 100% target usage. However, the sputtering rate is much slower than magnetron methods. Magnetron sputtering applications have a high rate, but use a maximum of only 50% of the target. Following the shape of the magnetron, the target material is consumed in an oval shape (called a racetrack), leaving the remaining material untouched.

Conclusion

The key to choosing the right power supply is fully understanding the implications of each approach and then determining which one best aligns with your particular priorities. For guidance on making a decision for your specific application needs, please contact sales.support@aei.com.

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