

PRECISE POWER CONTROL IN 3D DEVICE ARCHITECTURES

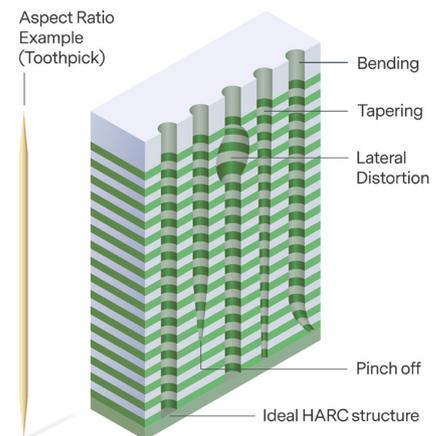
THE CHALLENGE

As memory structures continue to exploit three-dimensional processing, etch and deposition process schemes are leveraged to make ever taller stacks to increasingly precise specifications. Process power plays an essential role enabling complex architectures with atomic-scale features to be formed accurately with minimal defects.

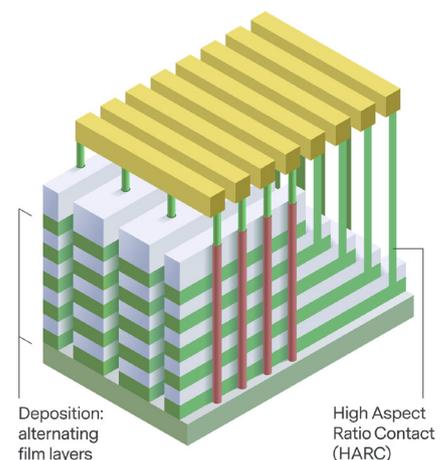
Selection of RF power frequency and precise, reproducible power regulation (generator power output and power delivered to the plasma) are critical to controlling thin film deposition thickness, density, and stress while ensuring high deposition rates for maximized process throughput and productivity.

The challenges of etching perfectly straight holes and complex 3D logic structures are also problematic. Etching tall, multi-layer stacks requires specialized multi-frequency RF and synchronized RF pulsing along with complimentary matching capability to control not only power to the plasma but surface effects such as charge accumulation. Increasingly complex recipes and shortening step times in deposition focuses further attention on agile tuning to ensure accurate power delivery.

Forming tall memory stacks and complex 3D logic structures has driven etch and deposition processes to increasingly complex multi-step recipes. Transitions between steps in modern processes often involve major changes to power level, gas flows and pressure, and consequently produce sharp changes in plasma impedance managed by the process power system. Ensuring consistent, accurate power delivery throughout these complex recipes, often including dozens of steps with abrupt impedance excursions, is a challenge facing modern process power systems in the 3D processing era.



A 3D NAND vertical structure with common High Aspect Ratio Contacts (HARC) etch issues (with the ideal HARC at the furthest left)



Deposition and film layers with HARC

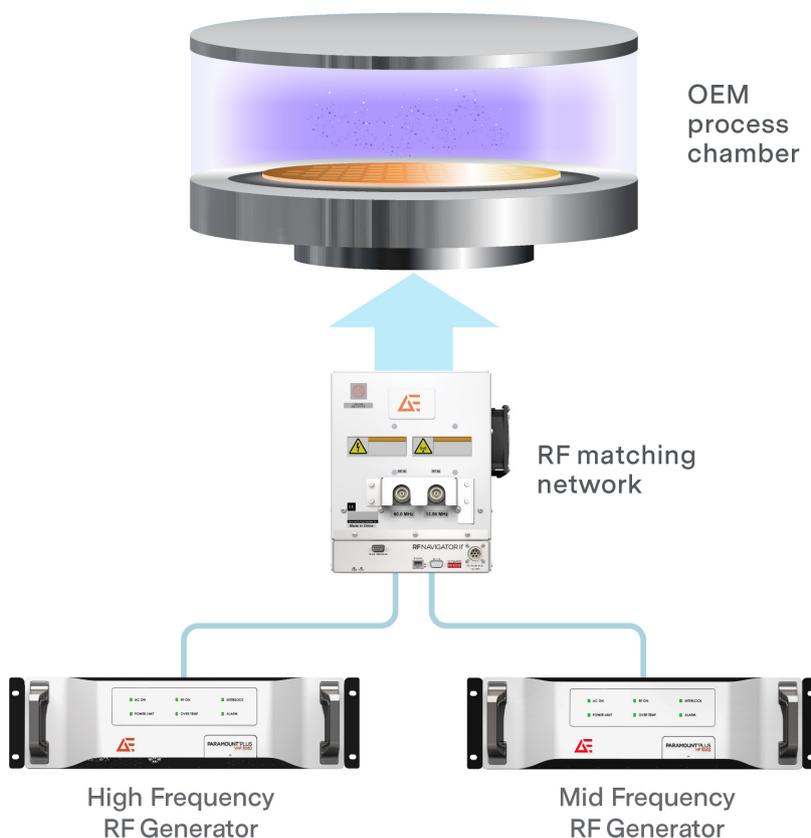
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APPLICATION COMPLEXITIES

Pairing RF Generators and Matching Networks

Combining different RF frequencies on a common electrode provides advantages for achieving efficient plasma production and high biasing voltages. These are essential for 3D structure formation, but multiple energy sources, pulsing, and operating at different frequencies, present further challenges for the process power system.

Interactions can present matching, measurement and regulation issues to name a few, but the process advantages make it imperative for today's process power systems to overcome these effects. Innovation in power delivery and impedance matching must keep pace with process innovation to allow these complicated RF delivery schemes to achieve the control and performance necessary in today's highly complex 3D device fabrication processes.



Advanced Energy's precision RF power delivery systems utilize all-digital, high-speed metrology and control, paired with the latest in matching technology, featuring advanced, agile, pulse enabled, model-based tuning. Proven switch-mode design and leading-edge, solid-state architectures bring reliable, stable, and efficient power delivery to plasma processes at drastically reduced size and cost.

OUR SOLUTIONS

Keeping pace with rapidly changing plasma processing requirements, power delivery systems such as the Paramount® Plus and Navigator® II now include all-digital controls with the ability to provide frequency tuning, complex pulsing profiles and the agility to tune-while pulsing. With the generator and match working together as a system, combining multiple frequencies on a common electrode enables process regimes for 3D device fabrication.

Etch and deposition equipment designers need RF power systems to provide the speed of response and fully automated tuning across changing process steps. Today's power generators must deliver variable frequency, precise regulation, pulsing and other advanced features to enable enhanced control of the plasma environment, while matching systems must offer capability to operate in pulsed, variable frequency conditions and handle the rapidly changing plasma impedances common in today's recipes.

Once reliable and stable power delivery for plasma processes is established, etching tall stacks with higher accuracy and fewer defects becomes standard.



Advanced Energy's Paramount Plus RF Plasma Power Generator



Advanced Energy's Navigator® II RF Matching Network

BENEFITS

- Precise control RF with enhanced plasma stability
- Faster response in a smaller space
- Maintain plasma without latency
- Tunes while pulsing using super fast sub-microsecond regulation
- Integrated RF: topology + metrology + connectivity in a single solution



ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

PRECISION | POWER | PERFORMANCE

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