

Flow and Thermal Characteristics of a Next-Generation Inductively Coupled Plasma Source

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Abstract

Radio-frequency inductively coupled plasmas (RF-ICP) are widely used across analytical chemistry and materials processing due to their stable, electrode-free operation. Conventional ICP torches employ a cylindrical quartz tube with three gas-injection ports, typically supplying argon. Because Joule heating is concentrated near the tube wall, substantial sheath gas flow is required to stabilize the plasma and protect the confinement surface. A recently developed torch design replaces the cylindrical geometry with a conical structure, enabling more efficient electromagnetic coupling and improved thermal confinement. This configuration significantly reduces the required gas flow rate and RF power while producing higher plasma temperatures and enhanced process stability. The presentation compares the performance characteristics of cylindrical and conical ICP torches, highlighting differences in power deposition, gas dynamics, and thermal profiles, and examines how these geometric modifications expand the capabilities of RF-ICP systems in advanced materials processing applications.