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Three-coil inductively coupled plasma (ICP) source with individually controlled coil currents supplied from a single power generator
LEONID DORF, SHAHID RAUF, JONATHAN LIU, JASON KENNEY, STEVEN LANE, ANDREW NGUYEN, KARTIK RAMASWAMY, KEN COLLINS, Applied Materials — As requirements on plasma uniformity get more stringent in the semiconductor industry, an ICP source with 3 coils becomes warranted. Designing a power distribution/50Ω-tuning network (PDN) that delivers the power from a single generator to 3 coils is complicated, due to inductive coupling between the coils, and between coils and plasma. Our PDN comprises several capacitors, including 2 variable ones, $C_{1,2}$, connected in parallel to 2 coils. A set of equations for coils/plasma currents was solved over a wide parameter space to determine practical values/ranges for all capacitors. It was shown that by moving along a pre-determined programming path in $C_{1,2}$ space, one can attain various coil current ratios (CCR) without crossing resonance curves. The latter causes coil current reversal, which may result in plasma instabilities and affect uniformity. Based on modeling results, the PDN was built and tested using a specially made 3-coil source. A wide range of CCR was achieved by varying $C_{1,2}$, including maxima or minima in any 2 coils. With slight adjustments (to account for parasitics and actual plasma coupling), the model correctly predicted experimentally observed CCR for each tested $C_{1,2}$ pair. Likewise, the theoretical resonance structure was reproduced experimentally with good agreement.

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