Resonant rf network antennas for inductively-coupled plasma sources

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Resonant rf networks are new and versatile plasma sources with numerous potential applications in plasma processing. They consist of parallel arrangements of $L,C$ elementary meshes with a set of resonant frequencies corresponding to the normal modes for the current/voltage distributions. Very high currents are generated within the antenna structure at a resonant frequency, which can therefore be used as a source for inductively-coupled plasma (ICP). This work gives examples of a closed network as a cylindrical source, and an open one as a planar source. The closed antenna (birdcage coil) is well known from nuclear magnetic resonance applications where the rf field is used to excite the nuclear spins in a sample. Other elementary mesh arrangements could be envisaged to form complex rf antennas adapted to specific applications.

The plasmas produced by the resonant networks show an $E$-$H$ transition similar to ICP devices using solenoids or spiral coils. Resonant rf networks used as large area or large volume plasma sources have particular advantages because their dominantly real impedance near resonance avoids high reactive voltages or currents, regardless of the network dimensions. By adding a static magnetic field, resonant networks also open the way to novel, wave-excited plasma sources, comparable to helicon sources but without the constraint of a cylindrical geometry. For example, the high efficiency of planar resonant rf networks for launching whistler-wave heated discharges \cite{1} means that plasma generation is not limited to a small skin-depth region, in contrast to ICP sources.

The general principle of resonant networks for plasma sources opens up a rich field of study for the plasma physics community. Many new permutations of plasma source physics could potentially evolve from this concept.