Plasma Varactor for Reconfigurable RF/Microwave Systems

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A weakly ionized plasma is a dispersive electromagnetic medium whose properties mainly depend on the plasma electron number density, gas type and pressure, and the operating frequency. Such properties include permittivity and electrical conductivity of the quasi-neutral bulk plasma region in the middle of the interelectrode gap as well as thicknesses of the charged sheath layers in contact with the electrodes. The sheaths' RF properties are close to those of vacuum capacitors whose capacitance can vary depending on the plasma conditions. Therefore, depending on the regime, plasma devices can be used as either a varactor or a variable resistor (or both) for those high-frequency applications where other tuning technologies are suboptimal due to high power, high temperature, linearity constraints or harsh environmental conditions.

The focus of this talk is on the proof-of-concept of plasma-based varactors, using either dc or RF for plasma excitation. In dc case, increasing the magnitude of discharge current in abnormal glow discharge regime results in shrinking of the sheath layer. Since plasma sheath behaves mainly as a capacitor due to its low electron density, this property can be employed to make a dc current-controlled RF varactor. A *LC* resonator circuit where a commercial gas discharge tube (GDT) serves as a variable capacitor was investigated experimentally and theoretically to show this effect. This sample *LC* resonator was tuned by 55% in the range of 240–372 MHz, while the discharge current increased up to 90 mA. On the other hand, RF sheath thickness also depends on the frequency of plasma excitation field. Hence, changing the frequency of plasma excitation signal could also results in variable capacitance. To study this phenomenon, the same LC resonator was employed, this time the GDT was ignited by a kHz-range electric field instead of the dc one. It was observed that by changing the frequency of the plasma excitation signal in the range of 1-1200 kHz, the measured resonant frequency of the LC resonator tuned in the range of 410 MHz to 300 MHz, proving the concept of frequency-controlled plasma varactor.