Plasma-Based Reconfigurable RF Electronics

Abbas Semnani, Sergey Macheret, and Dimitrios Peroulis
Purdue University
e-mail: asemnani@purdue.edu

***Abstract* — Low temperature (cold) plasmas can potentially be used to achieve high frequency tunability of RF systems. Since the permittivity and conductivity of weakly ionized plasmas are frequency-dependent parameters which also vary with the electron number density and gas pressure, the effective thickness and/or electromagnetic properties of a cold plasma region can be altered by changing the gas pressure and/or properties of the plasma excitation signal. A key parameter is the plasma frequency, ω_p, determined by the electron number density. If the operating frequency $\omega << \omega_p$, plasma behaves as a conductor and EM waves cannot penetrate into it. However, if $\omega >> \omega_p$, plasma would be transparent to the EM waves. In the range between these two extremes, plasma behaves as a lossy dielectric medium and EM waves are attenuated passing through it. Therefore, by working in a proper plasma regime, it is possible to ensure high frequency tunability. An important advantage of plasma-based electronics compared with solid-state solutions is the inherent capability of plasmas of handling high power and working under high temperature conditions. In this talk, we review the electromagnetic properties of weakly ionized low temperature plasmas and discuss proof-of-concept demonstrations of plasma tunable RF devices including tunable resonators, variable attenuator and reconfigurable power limiter. In these designs, gas discharge tube or plasma jet are integrated as RF variable capacitors in high frequency structures, and tunability is achieved by changing plasma excitation voltage. The measured and simulated results reveal that this approach may become a promising tuning technology particularly in demanding applications where conventional solid-state techniques are ineffective due to temperature, power, or linearity limitations.**