High-Power Microwave Tunable Resistor Based on Low-Temperature Plasma Technology

Abbas Semnani*, Sergey O. Macheret, and Dimitrios Peroulis
Purdue University, West Lafayette, IN 47907

In microwave gas breakdown and plasma formation, the initially insulated air gaps are converted into conductive regions. Although this phenomenon can be a destructive one that limits power handling of high-frequency devices and circuits with small gaps, it can also be utilized for some high-power tunable applications such as attenuators, limiters and switches. In fact, electromagnetic waves approaching a plasma region can be entirely transmitted, partially attenuated or totally reflected depending mainly on the plasma electron density. Hence, it is possible to employ plasma as a high-frequency tunable resistor particularly for high-power applications where other tuning technologies are suboptimal. Microwave-induced plasma occurs in the so-called α–discharge regime which has much higher stability and much longer lifetime in comparison with dc plasma.

In this talk, our recent investigations of employing low-temperature plasma as a tunable resistor for high-power limiters and switches are presented. The employed structures are composed of high-*Q* evanescent-mode cavity resonators loaded with gas discharge tubes, as plasma cells, in its gap area over the post. In a proof-of-concept *S*-band limiter with 22% bandwidth, pre-ionization by an external dc bias provided 15.5 dB of limiting power tunability (from milliwatts up to tens of watts), while the limiter handled up to 100-W input power without any visible degradation in prolonged operation. Furthermore, a prototype 2-20 W single-pole single-throw switch at the frequency range of 2.8-3.9 GHz represented less than 1 dB of insertion loss with a tunable isolation in the range of 13 dB to 22 dB. The measured response time was on the order of 10s of ns, and the input third-order intercept point was +53 dBm. The limiting/switching mechanism is self-sustained and the level of isolation depends on the input power. Also, the mechanism is quasi absorptive since the required energy for the plasma ignition is supplied by the incoming electromagnetic waves.