High Power Microwave Slow Wave structure for Relativistic beams

Muhammed Zuboraj*, N. K. Nahar, Kubilay Sertel, J. L. Volakis
Electroscience Laboratory, The Ohio State University,
1330 Kinnear Road, Columbus, OH-43212, USA

High power RF sources are used in many applications including Satellite communications, Radar, Electronic Counter-Measures (ECM). Most of them consist of Klystrons, Magnetrons or Gyrotrons which are narrow band, bulky structures. Very few TWTs compatible with very high power (above 100KW) in S-band have been reported in literature. A challenge in designing small, high power TWTs relates to over-heating that counter the principles for designing slow-wave structures. Other difficulties lie in the formulating very high beam velocity using very small electrical lengths. More specifically, small electrical lengths do not interact efficiently with the incoming electron beam. Also, for large phase velocity waves, the interaction impedance decreases, causing lower gain and output power. With these challenges in mind, and with goal of reducing the size of TWTs, in this paper we investigate (1) novel slow-wave structures to achieve large RF phase velocity with moderate interaction impedance, (2) materials for structural stability to counter heating effects.

In this paper, we propose a modified Ring-Bar (RB) Slow Wave Structure (SWS) operating in the S-Band (2-4 GHz). The proposed TWT is compatible with high phase velocity electron beams and achieves moderate interaction impedance. The bending of the ring-bars produce stronger electric field at the center of beam, and the addition of more connecting bars within the RB-SWS produces significant desirable changes in the phase velocity and interaction impedance characteristics. The design is fully metallic to avoid dielectric discharge when operating at high power. A complete full wave analysis will be presented and used to study dispersion, phase velocity, interaction impedance, and E-field profile, among others features. A Particle in Cell (PIC) analysis will be also provided to portray the beam-wave interaction inside the TWT when operated in presence of relativistic beams. Further, thermal stress and mechanical stability analysis will be given to verify the final design's operation.