Session 23. Fabrication techniques / Materials

May 1 (Wednesday) / 13:30 ~ 15:10 / Room 2

Session Chair: Colin Joye (Naval Research Laboratory, USA)

13:30 ~ 13:50

23.1 / [Keynote] Copper Reconsidered: Material Innovations to Transform Vacuum Electronics

Diana Gamzina (SLAC National Accelerator Laboratory, USA), Michael Kozina (SLAC National Accelerator Laboratory, USA), Apurva Mehta (SLAC National Accelerator Laboratory, USA), Emilio A. Nanni (SLAC National Accelerator Laboratory, USA), Sami Tantawi (SLAC National Accelerator Laboratory, USA), Paul B. Welander (SLAC National Accelerator Laboratory, USA), Timothy Horn (North Carolina State University, USA), Christopher Ledford (North Carolina State University, USA)

Copper is critical to the manufacturing of vacuum electronic devices due to its high electrical and thermal conductivities. It enables high RF performance while maintaining low thermal losses. Copper is also responsible for some of the challenges: RF power output is often limited by the strength of copper and RF breakdown is induced by copper transformation at the vacuum surface. Recent advances in understanding of RF interaction with copper offer insight into its limitations and how they may be mitigated. Emerging manufacturing technologies, such as electron beam melting of copper, can be employed to achieve a stronger copper state in the RF structures, opening opportunities for higher power and more compact vacuum electronics. As copper focused additive manufacturing evolves, strengthening mechanisms can be incorporated into the material to produce desired material properties locally, further enhancing performance capabilities of vacuum devices.

13:50 ~ 14:10

23.2 / Characterization of W-band Serpentine Waveguide TWT Circuits

Reginald L. Jaynes (U.S. Naval Research Laboratory, USA), Alan M. Cook (U.S. Naval Research Laboratory, USA), Colin D. Joye (U.S. Naval Research Laboratory, USA), Edward L. Wright (Beam Wave Research, Inc., USA), Dean E. Pershing (Beam Wave Research, Inc., USA), Khanh T. Nguyen (Beam Wave Research, Inc., USA)

We present experimental characterization of W band serpentine waveguide TWT circuits fabricated by CNC micro-endmill machining. Cold test measurements of S-parameters demonstrate excellent agreement with simulation and precise fabrication repeatability between multiple circuits. The circuit wavelength dispersion was measured in both W- and D-band waveguide bands, covering an octave in frequency, showing agreement with simulation from 85-170 GHz. We discuss details of the fabricated circuits and cold test results.

14:10 ~ 14:30

23.3 / Research on high thermal conductivity and low loss tangent aluminum nitride ceramics

Yang Yan-ling (Beijing Vacuum Electronics Research Institute, China), Lu Yan-ping (Beijing Vacuum Electronics Research Institute, China)

In this paper, a high thermal conductivity and low loss tangent AlN ceramics was prepared. The developed AlN has a dielectric constant of 8.42, the loss tangent of 5×10^{-4} (35GHz), thermal conductivity at room temperature is 186 W/(m·K). The developed AlN ceramic can not only meet the requirements of the microwave window, but also can be applied to be collector and clamp-pole in the microwave tube.

14:30 ~ 14:50

23.4 / Secondary electron emission of (Mg-Zn-O)/(MgO-Au) bilayer composite film deposited by sputtering

Jie Li (Xi'an Jiaotong University, China), Wenbo Hu (Xi'an Jiaotong University, China), Qiang Wei (Xi'an Jiaotong University, China), Shengli Wu (Xi'an Jiaotong University, China), Yongdong Li (Xi'an Jiaotong University, China), Huiqing Fan (Northwestern Polytechnical University, China)

(Mg-Zn-O)/(MgO-Au) bilayer composite film was proposed, and the influence of Zn-doping concentration on the surface morphology, electronic structure and electron-induced secondary electron emission (SEE) performance of this composite film was investigated. The investigation results show that the Zn doping with a low concentration in the MgO surface layer brings about the enlargement of grain size and the reductions of both bandgap and work function of MgO, which leads to the superior SEE performance owned by (Mg-Zn-O)/(MgO-Au) composite film.

14:50 ~ 15:10

23.5 / Circuit Fabrication Methods for Millimeter-Wave Vacuum Electronics

Colin D. Joye (U.S. Naval Research Laboratory, USA), Alan M. Cook (U.S. Naval Research Laboratory, USA), Reginald L. Jaynes (U.S. Naval Research Laboratory, USA), B. Spence Albright (U.S. Naval Research Laboratory, USA), John R. Lowe (U.S. Naval Research Laboratory, USA), John C. Rodgers (U.S. Naval Research Laboratory, USA), Jeffrey P. Calame (U.S. Naval Research Laboratory, USA), Scooter D. Johnson (U.S. Naval Research Laboratory, USA)

We report on fabrication techniques for creating vacuum electron (VE) circuits from 30 GHz to 300 GHz. For devices up to 300 GHz, micro-CNC machining appears suitable.