Poster 1

April 29 (Monday) / 15:10 ~ 16:30 / Capri room

Fabrication techniques / Materials

P1-6.1 / Influence of Diamond on Heat Dissipation Capability of The Helix Slow-Wave Structures

Yanwen Liu (Chinese Academy of Sciences, China), Hong Tian (Chinese Academy of Sciences, China), Yu-Xin Lu (Chinese Academy of Sciences, China), Wenqi Shi (Chinese Academy of Sciences, China)

Heat dissipation capability of helical slow-wave structure is an important factor that affects output power, operating stability and reliability of travelling-wave tube (TWT). As diamond material has superbly high thermal conductivity, use of it in fabricating helical slow-wave structure is able to improve heat dissipation capability of the component to some extent. By means of theoretical calculation, simulation & emulation and laboratory test, this paper studies influences of diamond-film- deposited support rod, diamond-film-deposited helix and diamond support rod on heat dissipation capability of slow-wave structure. With a contrast study of experiment and simulation data, the computer simulation is closely correlated to experimental test, which improves the accuracy of computer simulation research and offers important references for application of diamond material in slow-wave structure.

P1-6.2 / Study of A Nanocrystalline Diamond for Composite Diamond Windows in THz TWTs

Ming Q. Ding (Beijing Vacuum Electronics Research Institute, China), Lili Li (Beijing Vacuum Electronics Research Institute, China), Chengyi Hua (Beijing Vacuum Electronics Research Institute, China), Jun Cai (Beijing Vacuum Electronics Research Institute, China), Jinjun Feng (Beijing Vacuum Electronics Research Institute, China)

Previously we have developed an extremely thin composite diamond film for THz TWT windows by incorporating ultrananocrystalline diamonds (UNCDs) into microcrystalline diamonds (MCDs). Given that the processing conditions for UNCD differ from those of MCD, we investigated a process of nanocrystalline diamond (NCD) as an alternative to UNCD. This type of NCD is grown at relatively high substrate temperature (~870^{0}C) under the same gas mixture (CH4/H2) as MCD that the fabrication processing can be facilitated. Testing results show that the fabricated NCD films have an average mechanical strength of 1565±88 MPa, no less than UNCD.

P1-6.3 / Low Secondary Electron Yield Materials For Space Applications Based on Ab Initio Computation

Min Peng (Xi'an Jiaotong University, China), Yongdong Li (Xi'an Jiaotong University, China), Chunliang Liu (Xi'an Jiaotong University, China), Dawei Wang (Xi'an Jiaotong University, China)

Anti-multipactor in space microwave devices is of great significance in a vacuum environment. It contributes to overcome one important limiting factor, i.e, the high secondary electron emission (SEE), which threatens the safety of various microwave devices in spacecrafts. In this paper, based on existing models of SEE, the relationship between the secondary electron yield (SEY) and work function is discussed for metallic materials with different crystal planes. Furthermore, we have computed the work function for solid material surfaces and electron affinity for dielectrics using simulations, trying to establish a correlation between chemical constituents, atomic geometry and surface potential barrier of materials and to understand the influence of lattice structure and atomic arrangement on SEY. We have accurately computed the work functions of a few materials, including: (1) Work functions of metals and their oxides (with oxides showing higher maximum SEY); (2) Work functions for MgO and NiO single crystals, as well as superlattices made from them; (3) Work functions for metals (Cu, Ni) and graphene covered metals (Cu, Ni). Moreover, a method to avoid the sensitive area and reducing the SEY is proposed in the structure design, which is expected to come into experimental verification. At last, we focus on the scattering cross section underpinning most essential physical process of the secondary electron emission problem, and try to get a response from Monte Carlo simulation using the factors calculated above and the multi-generation model on rough surfaces.

P1-6.4 / W-band TWT Component Fabrication and Testing

Alan M. Cook (U.S. Naval Research Laboratory, U.S.A), Edward L. Wright (Beam Wave Research, Inc., U.S.A), Khanh T. Nguyen (Beam Wave Research, Inc., U.S.A), Colin D. Joye (U.S. Naval Research Laboratory, U.S.A), Frank. N. Wood (U.S. Naval Research Laboratory, U.S.A), B. Spence Albright, Jr. (U.S. Naval Research Laboratory, U.S.A), John R. Lowe (U.S. Naval Research Laboratory, U.S.A), Reginald L. Jaynes (U.S. Naval Research Laboratory, U.S.A), Jeffrey P. Calame (U.S. Naval Research Laboratory, U.S.A), David K. Abe (U.S. Naval Research Laboratory, U.S.A), Takuji Kimura (CPI, U.S.A), Galen Aymar (CPI, U.S.A)

We present fabrication and testing of RF components for a W-band serpentine waveguide TWT. Broadband ceramic RF windows and loads exhibit reflection lower than -20 dB across the TWT operating band, nominally 87-100 GHz. End-to-end cold test of the entire tube assembly, including interaction circuit, shows a clean passband better than -15 dB, in agreement with simulation. We discuss details of the fabricated components and electromagnetic cold test results.

P1-6.5 / 3D Printing of Microwave Attenuating of FeSiAl Materials

Yingqin Liu (Chinese Academy of Sciences / University of Chinese Academy of Sciences, China), Yongqing Zhang (Chinese Academy of Sciences, China), Guanghua Li (Chinese Academy of Sciences, China), Xiangjun Wang (Chinese Academy of Sciences, China), He Jin (Chinese Academy of Sciences, China), Xiangyang Gao (Chinese Academy of Sciences, China), Bofeng Wang (Chinese Academy of Sciences, China)

In this paper, we propose a novel method to prepare FeSiAl coatings. This method is laser 3D

printing technology of FeSiAl powder. Research shows that the FeSiAl coatings prepared by laser 3D printing still have good microwave attenuation performance.

P1-6.6 / Dielectric Material for the Electron Accelerator Vacuum Chamber

Tae-Yeon Lee (Pohang Accelerator Laboratory, Korea), Taekyun Ha (Pohang Accelerator Laboratory, Korea)

Ever since the first particle accelerator appeared in the early twentieth century, the vacuum chamber of any accelerator has been made of metals such as stainless steel or aluminum. These metals have not only an advantage of maintaining ultra-high vacuum but other advantages such as strength and durability. However, the image current induced on the metal chamber surface by charged particles moving inside the chamber is a main cause for instabilities occurring inside the charged particle beam. This paper shows that dielectric vacuum chamber made of such materials as ceramic or glass can be used for electron accelerators without generating image current and instabilities. This paper also shows how to resolve problems coming from dielectric vacuum chamber including charging effect and static charges.

P1-6.7 / Work Function and Electronic Structure Measurements on Nitrogen-Doped LaB_6 Thin Film by Scanning Tunneling Microscope

Katsumi Nagaoka (National Institute for Materials Science, Japan), Shun-ichiro Ohmi (Tokyo Institute of Technology, Japan)

Lanthanum hexaboride (LaB_6) is one of the most widely used low work function materials. However, for realizing the lowest work function of 2.3 eV, the single crystalline bulk material had been persuaded to be absolutely necessary for preventing surface degradation by oxidation. But, recently, a LaB_6 thin film exhibiting the low work function has been developed with radio frequency (RF) sputtering deposition using a nitrogen-doped (N-doped) LaB_6 target. Here we report an experimental study on the work function and electronic structure measurements on the 20 nm-thick N-doped LaB_6 thin film. We found, even after air exposure, annealing at 500 ℃ revived the work function of 2.35 eV and the local electronic structure consistent with the previous studies on the clean pristine single crystal. Our results demonstrate the N-dope LaB_6 thin film does not only maintain the fundamental properties of the pristine material but also greatly facilitate the handling. We anticipate that the N-doped LaB_6 thin film enables to extend the application scope of the LaB_6.

P1-6.8 / A microwave plasma jet chemical vapor depositionfor diamond film growth

Chun-Yu Lin (National Taipei University of Technology, Taiwan), Jing-Shyang Yen (National Taipei University of Technology, Taiwan), Hua-Yi Hsu (National Taipei University of Technology, Taiwan), Ming-Chieh Lin (Hanyang University, Korea)

The research and development of a microwave plasma jet chemical vapor deposition for diamond film growth have been carried out in this study. This three-dimensional microwave

plasma model helps understanding the operating conditions for the growth of diamond film. This mathematical modeling uses an adaptive finite element numerical method based on different parameters. Plasma simulation has been considered as a numerically stiff problem because of the strong nonlinearity and multi scales crossing. The whole system has been modeled soundly. Also, the thin diamond film has been successfully fabricated according to the identical condition. The SEM image shows that the deposited diamond particles are uniformly distributed on the substrate with the size of 1 μm which might find application in surface hardening and field electron emission.

P1-6.9 / Local work functions of magnetite under electric fields based on first principle calculations

Liangliang Xu (Hanyang University, Korea), Nan Zhao (Hanyang University, Korea), Ming-Chieh Lin (Hanyang University, Korea), Tsan-Chuen Leung (National Chung Cheng University, China)

Magnetite is a mineral and one of the main iron ores. With the chemical formula Fe_3O_4, it is one of the oxides of iron. Magnetite is the earliest discovered magnet, around 1500 B.C. It crystallizes in the inverse cubic spinel structure (Fd3m) above the so-called Verwey transition temperature which is about 120 K. In this work, we study the electronic properties of magnetite (100), (110), and (111) surfaces under external electric fields using first principles or ab initio calculations based on density functional theory. With an electric field applied, the effective work function changes under different field strength. By calculating the local work function, we can know the distribution of work function on a certain surface. The effective work functions of magnetite Fe_3O_4 on different surfaces have been determined. The local work function has been found to have the correspondences with the atoms' positions and charge densities. In addition, the deviation in local work function ($\Delta\varphi$) increases proportionally to an increasing electric field up to 0.2 V/A. It is proposed that the magnetite as a half-metal can possibly be used as a spin-polarized electron source.

P1-6.10 / Local work functions of clean tungsten surfaces under electric fields based on ab initio calculations

Yue Wang (Hanyang University, Korea), Liangliang Xu (Hanyang University, Korea), Ming-Chieh Lin (Hanyang University, Korea), Tsan-Chuen Leung (National Chung Cheng University, China)

Tungsten, the common choice for vacuum tube filaments, can survive under high temperatures and provide thermionic emission of electrons. However, the emission is largely limited due to its relatively high work function (approximately 4.5 eV). First principles or ab initio calculations are used to study the local work functions of tungsten (W) clean (100), (110), and (111) surfaces under external electric fields. The authors have systematically tested the convergence of density-functional-theory (DFT) calculations in the local-density approximation (LDA) and generalized-gradient approximation (GGA) with a plane-wave basis set the projector-augmented wave method as implemented in the Vienna Ab-initio Simulation Package (VASP). Several pseudo-potentials have been tested for comparison. With the tungsten model under electric fields applied on both sides, we can investigate the dependence of the local work function and

effective work function on field strength. In addition to thermionic emission, tungsten has been considered for use as a field emission (FE) electron source.

P1-6.11 / Twin Growth in RF Window Ceramic as a Criterion for the Response Time of Protection System in High Power Vacuum Tubes

Shahriyar Kaboli (Sharif University of Technology, Iran)

The ceramic fracture in output RF window is one of the most important failure factors in high power microwave sources. Fast protection systems are used to protect the source. The methods for determining the required protection response time are conservative and rough. In this paper, an investigation is presented about the twin growth in the ceramic of RF window in faulty condition. It is shown that the twin growth in ceramic can be a reliable figure of merit for the response time calculation of the microwave source protection system.