Design and Development of Thermionic Emission Microscope

RK Barik*, RS Raju, Supriyo Das, and Sneh Rathore

Central Electronics Engineering Research Institute (CEERI), Pilani (Raj.) - 333 031, INDIA
(a constituent R&D laboratory of Council of Scientific and Industrial Research (CSIR))
**School of Electrical Engineering and Computer Science, Seoul National University, South Korea*
<ranjan.ceeri@gmail.com>, <raju.ceeri@gmail.com>, Ph.: +91-1596-252437, fax: -242294

Abstract: *Thermionic Emission Microscope (THEM) developed at CEERI has an electrostatic immersion lens to magnify the image. The geometry of lens and potentials are optimized to achieve a magnification of about 15 times with a clear image. The design of deflection plates and lens are carried out using OmniTRAK 3-D to ensure required deflection of beam without losing laminarity and beam interception with plates. Faraday cage, containing a narrow aperture, is designed to obtain elemental currents with low secondary emission. The emission picture of a B-Type cathode has been obtained. The results are satisfactory.*

Keywords: THEM, OmniTRAK, Dispenser cathode

Introduction

The surface of Dispenser cathode is composed of low work function sites, which dominate the emission, surrounded by high work function sites. Thermionic Emission Microscope (THEM) is a tool to study the spatial emission distribution of cathode [1]. A schematic diagram showing various modules of THEM is shown in Fig. 1. The system has an electrostatic immersion lens to produce the image of cathode emission; deflection plates to deflect the beam; and Faraday cage to collect the elemental currents. The image of the cathode is magnified by applying, typically, –10 kV to the cathode. The cathode is operated under saturated conditions; and, the image is formed at the screen due to the electrons emitted by the cathode surface. The emission picture could be seen on a phosphor screen. In the present approach, the image is deflected in small increments of X- and Y-deflection and the corresponding micro-current samples in each step (of raster scan) are captured through the aperture of Faraday cage and amplified by trans-admittance amplifier, which are fed to PC. The data are plotted in the form of emission maps and work function histograms. The basic difference between a THEM and a SEM is that in the former the object is the emitting area whose image is magnified through lens system; while, in the latter, the object could be any specimen whose secondary emission image is obtained.

Design approach

The simulation is carried out in two stages by: (a) TRAK (2-D model), and (b) OmniTrak (3-D model) - both of which are suited for the study of charged particle optics. The 2-D model is used for simulation of lens system and for obtaining electron trajectories; while, 3-D model is used for deflection system to estimate beam deflection.

The aim of present simulation studies is to optimize the: (a) lens by proper choice of inter-electrode distances to get a laminar beam and (b) deflection system by properly varying the radial and axial dimensions of both X- & Y- plates and their positions w.r.t. the lens to minimize beam interception. The trajectory plots are made for different sets of geometrical and voltage parameters by which the extent of deflection is estimated. The extend of deflection is estimated by taking the difference between no-deflection condition and deflection condition. For confirmation, analytical equations are also used for a rough estimation of deflection. The geometry of lens and potentials are optimized to achieve about 15 times image magnification with good laminarity. One of the simulated images at a deflection voltage of 500V is shown in Fig. 2, and its 3-D plot is shown in Fig. 3.

Experimental work and Discussion

The photograph of THEM is shown in Fig. 4. To estimate the size of image and deflection, the collector plate (where beam falls) is scaled by proper markings. During operation, the cross-section of beam at collector plate could be visualized in the form of bluish glow through the glass window of the vacuum chamber. The measured figures are in close agreement with the simulated results. One of the emission maps of B-type cathode is given in Fig. 5. The laminarity of beam under deflected condition (Fig. 3) is checked. It is found that there are no cross-over of trajectories even at the extreme deflection voltages.

For deflecting the beam, two ramp signals –10 to +10 V are generated using a data acquisition card through PC for raster scanning. These are amplified using DC amplifier and are fed to the

X- & Y- deflection plates. The signal (output of Faraday cage) is amplified using a transadmittance amplifier. This signal is used under two modes, *viz* (1) Visual mode and (2) Data acquisition mode. Under Mode-1, the image is focused by adjusting the lens spacings and their voltages. Under Mode-2, the data, obtained from Faraday cage, are fed to PC for plotting emission map and work function histogram.

Reference

1. RS Raju, "Impregnated cathodes for use in high power microwave tubes", Ph.D. Thesis, Univ. of Cambridge, U.K., 1987.

Acknowledgement

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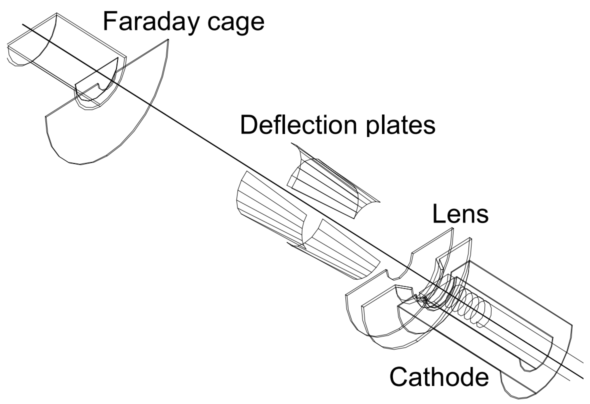

Figure 1. Schematic diagram of THEM

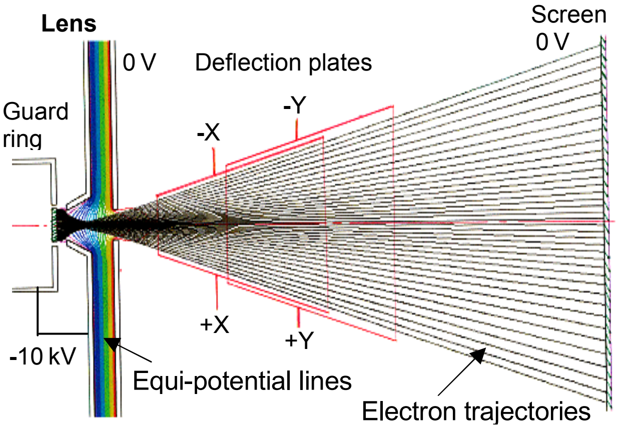

Figure 2. Simulated results sing TRAK 2-D.

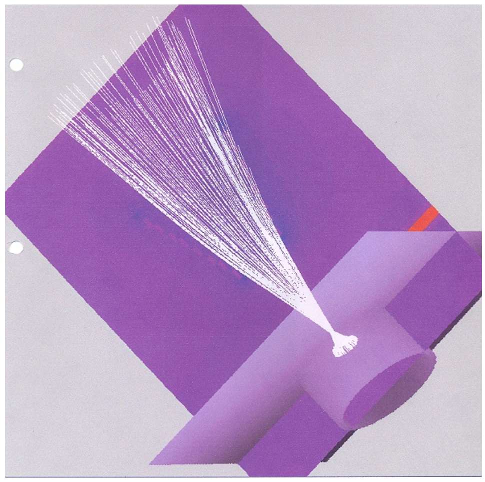

Figure 3. Simulated results sing OminTRAK 3-D.

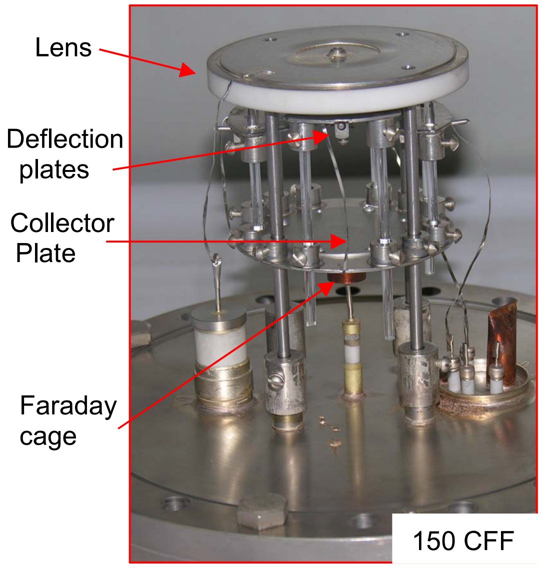

Figure 4. Photograph of THEM

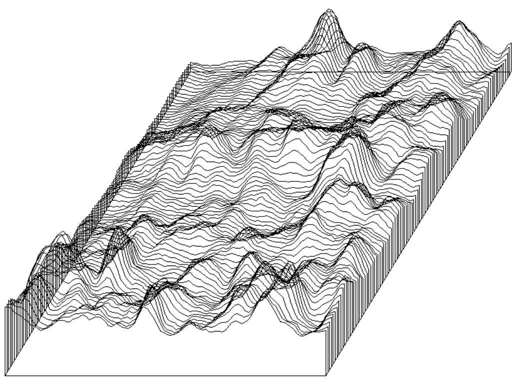

Figure 5. Emission Map of B-Type cathode