Title
A Simple Scanning Electron Microscope

Journal
Review of Scientific Instruments, 40(2)

ISSN
0034-6748 1089-7623

Authors
Crewe, A. V
Isaacson, M.
Johnson, D.

Publication Date
1969-02-01

DOI
10.1063/1.1683910

Review of the Workings of an Electron Microscope

Daniel Chen

Electrical and Computer Engineering, University of California Los Angeles, Los Angeles, USA

Abstract

The paper under review explains what components go into making an electron microscope and it goes into detail of how each part functions. This review is focused on how the electron gun component of the microscope works, specifically how the electrons used for the imagery process are generated. The paper concludes that electrically pumping a finely made tungsten tip is the most effective way to generate electrons for the microscope.

Introduction

Electron microscopes are the most powerful microscopes in the world and they are widely used in the industry. Their functionalities can range from studying "microorganisms" to performing "failure analysis".[1] Understanding how these tools functions opens up avenues for finding ways to improve on them.

In the course ECE 170A, held at UCLA, the fundamental photonic principles are taught. These concepts can be applied to describe the physics behind how an electron microscope works. One topic in particular that is covered is about the pumping of materials and the subsequent emission of electrons. This idea can be used to understand the electron gun section of the microscope and to fundamentally explain – from a physics point of view – how that component works.

Methods

In Figure 1, we can observe the general components used to create an electron microscope. At the top of the figure, we can see the part that actually makes up the electron gun. To qualitatively understand how this component works, we will refer to some basic principles of material emission and excitation:

1. Pumping a system involves "actively exciting the atoms in a low-energy level to a high-energy level". Moreover, a common pumping

[1] Horiba. (n.d.). *What is an electron microscope?* HORIBA. Retrieved March 10, 2022, from https://www.horiba.com/int/cathodoluminescence-spectroscopy-electron-microscope/#:~:text=Electron%20microscopes%20are%20used%20to,quality%20control%20and%20failure%20analysis.

technique is “electric current injection” which is how “semiconductor gain [mediums]” are often pumped.[2]

2. Spontaneous emission occurs when the upper level of a “system is populated, irrespective of the lower-level population.”[3]

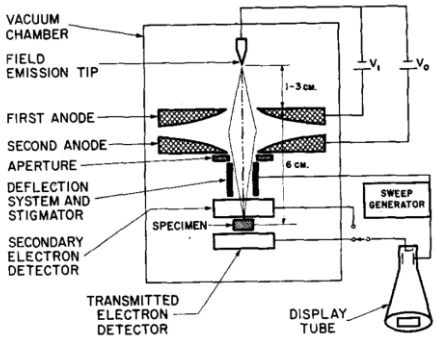

Figure 1: Breakdown of an electron microscope[4]

Results and Discussion

In the paper, it was found that tungsten was the best choice of material and that it performs well when electrically pumped. The researchers, however, could have expanded more on how applying the voltage across the tungsten actually emits electrons. Using the principles expounded under *Method* we know that applying a high voltage across the material electrically pumps it so that there are more electrons in the higher energy level. Moreover, the innate spontaneous emissions that occur will excite these high-potential electrons - effectively sending them out into the vacuum.

Conclusion

This paper goes into detail of the various components of an electron microscope. When designing the electron gun section, they found that electrically pumping a tungsten tip was the most effect way of generating electrons for the microscope. Although the paper clearly explained what parts and materials were selected to make the electron gun and their reasons for selecting those parts, the researchers did not explain *how* those parts were generating electrons. This review provides some of the information they could have implemented into their paper.

---

[2] Jia Ming Liu, *Principles of Photonics*, 249
[3] Jia Ming Liu, *Principles of Photonics*, 267
[4] Crewe, A. V., Isaacson, M., & Johnson, D. (1969), 577. A simple scanning electron microscope. *Review of Scientific Instruments, 40*(2), 241–246. https://doi.org/10.1063/1.1683910

Bibliography

Crewe, A. V., Isaacson, M., & Johnson, D. (1969), 577. A simple scanning electron microscope. *Review of Scientific Instruments*, *40*(2), 241–246. https://doi.org/10.1063/1.1683910

Horiba. (n.d.). *What is an electron microscope?* HORIBA. Retrieved March 10, 2022, from https://www.horiba.com/int/cathodoluminescence-spectroscopy-electron-microscope/#:~:text=Electron%20microscopes%20are%20used%20to,quality%20control%20and%20failure%20analysis.

Jia Ming Liu, *Principles of Photonics*, Cambridge University Press 2016