Issue 23 May 2011

InfoTracks

Semitracks Monthly Newsletter

Upcoming Webinar for EOS and ESD

Although EOS and ESD damage can at times look quite similar to each other, the source of each and the solution can be quite different…

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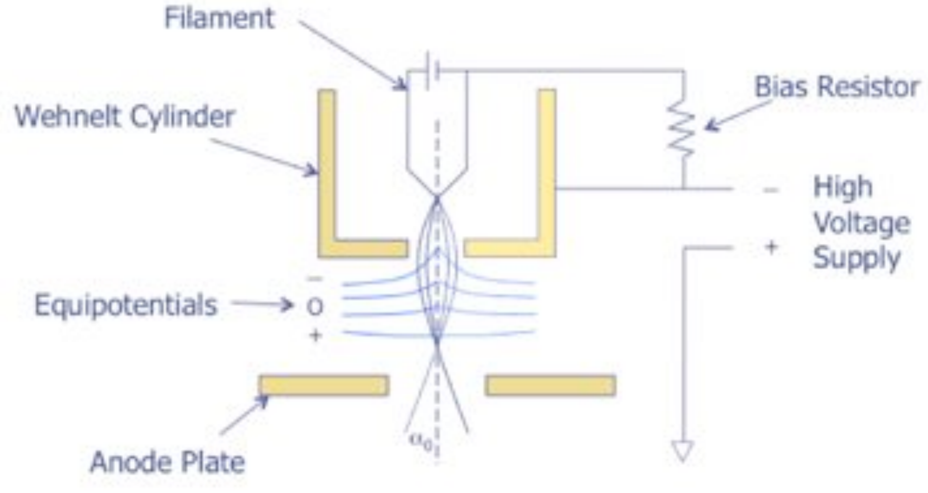
Electronic Gun Configurations for Scanning Electronic Microscopes

By Christopher Henderson

The Scanning Electron Microscope is a basic instrument for analysis and characterization. We will cover the basic configuration of the electron guns in this article. Scanning Electron Microscopes (SEMs) fall into three basic configurations, Tungsten, Lanthanum Hexaboride or LaB6 and field emission. Within the field emission category, there are two basic configurations: the cold cathode configuration and the Schottky Emitter configuration.



After Goldstein et. al.

Figure 1 shows the basics of a tungsten-based system. In a standard tungsten system, a bias is placed across the filament; the current through the filament heats it. At high temperatures, the material emits electrons, which can then be accelerated down the

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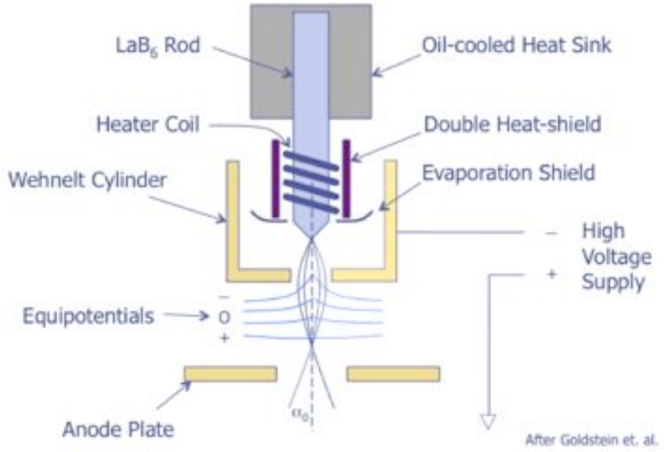
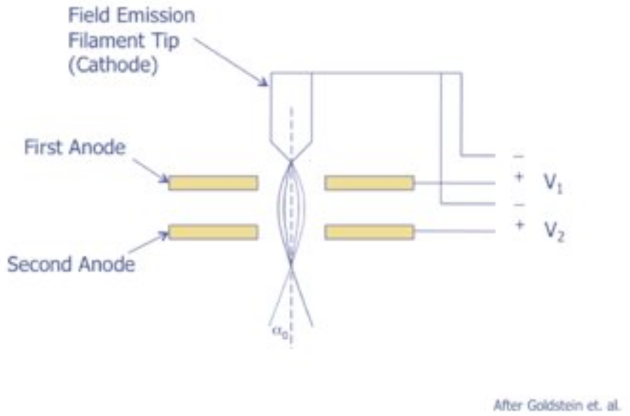
column. The high voltage power supply between the Wehnelt cylinder, filament, and anode plate determines the primary electron beam energy.



After Goldstein et. al.



After Goldstein et. al.

Figure 2 shows the basics of a lanthanum hexaboride system. Lanthanum hexaboride, also known as LaB6, emits a higher number of electrons than a tungsten filament, permitting higher quality images. In this gun configuration, a heating coil encompasses the LaB6 rod to heat it. As with the tungsten system, the high voltage power supply lies between the Wehnelt cylinder and anode plate to determine the primary electron beam energy.

Another method for generating electrons is the field emission gun. A schematic of a field emission tip is shown in Figure 3. When the cathode forms a very sharp tip (typically 100 nm or less) and the cathode is placed at a negative potential with respect to the first anode so that the local field at the tip is very strong (greater than 10 to the 7 Volts per centimeter), electrons can tunnel through the potential barrier and become free. Although the total current is lower than either the tungsten or the LaB6 emitters, the current density is between 10 to the 3 and 10 to the 6 Amps per centimeter. Thus, the field emission gun is hundreds of times brighter than a thermionic emission source. Furthermore, since the electrons are field generated rather than thermally generated, the tip remains at room temperature. Tips are usually made from tungsten etched in the <111> plane to generate the lowest work function. Because a native oxide will quickly form on the tip even at moderate vacuum levels (10 µPa), a high vacuum system (10 nPa) is needed. To keep the tip diameter sufficiently small, the cathode warmed to 800-1000 °C or rapidly heated to approximately 2000 °C for a few seconds to blow off material.

This table below summarizes the basic capabilities of the four basic configurations, where we break the cold field emission and Schottky field emission systems into their own separate groups. The highest performers are the field emission systems, which include cold cathode and Schottky. The high brightness and sharp tip leads to high resolution and longer source lifetimes. Notice that both tungsten and LaB6 have lower brightness, lower resolution, and reduced source lifetimes. However, the lower vacuum requirements can facilitate more rapid sample exchange, especially when venting the column is necessary. For more information on the Cold Cathode and Schottky field emission systems, please see the Technical Tidbit on this topic elsewhere in this newsletter.Higher tunnel magneto resistance improved the read speeds to on the order of 10 nsec. Unfortunately, the current needed for MRAM devices increases as the dimensions decrease, limiting the usefulness of this type of device.

Source	**Tungsten**	**LaB$_6$**	**Cold FE**	**Schottky FE**
Vacuum (torr)	10^{-5}	10^{-7}	10^{-10}	10^{-8}
Brightness (A/cm^2-sr)	10^{+5}	10^{+6}	10^{+8}	10^{+8}
Resolution (nm)	10	5	1	1
Source Lifetime (hours)	40-100	200-1000	>1000	>1000

Ask the Experts

Q: Is there a standard for SEU testing?

A: Yes there is. JEDEC issued JESD-89 in 2007 to cover SEU testing. There are several parts to the document; be sure to read each one so you know how to apply the testing to your situation.

To post, read, or answer a question, [visit our forums.](#)
We look forward to hearing from you!

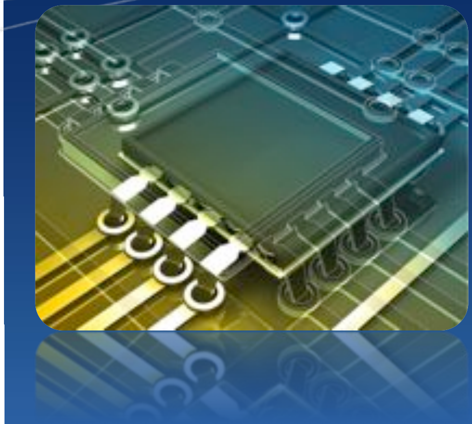
AMFA 2011

ADVANCED MATERIALS & FAILURE ANALYSIS

August 29, 2011
Boston, Massachusetts

The 6th Annual AMFA is just around the corner! Please plan now to attend; registrations are open until June 30th. Semitracks' President Christopher Henderson will be running the event this year.

Learn more about this conference at:
http://www.amfaworkshop.org/



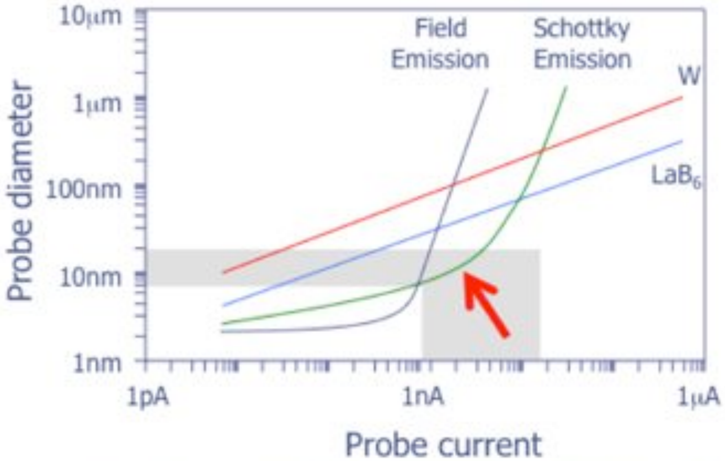
EOS in Manufacturing Webinar

Electrical Overstress (EOS) and Electrostatic Discharge (ESD) account for most of the electrical failures of devices that occur in factories and in the field.. The effects of ESD on integrated circuits have received much attention in technical literature, standards bodies and educational workshops and tutorials. The problem has been approached in a systematic manner which has resulted in relatively successful practices for design of robust devices and control procedures for the factory. However, the same cannot be said for the effects of the broader categories of electrical stresses generally referred to as electrical overstress (EOS). This disparity is reflected in the typical Pareto analysis of failures in electrical assembly where EOS is often the most commonly assigned cause of failure and may exceed the incidence of ESD by 10 times or more. One of the main reasons for this is that EOS sources are widely varied and very application dependent. As a result, no simple broad models for EOS have emerged comparable to HBM and CDM for ESD. Common device design practices have not been developed to the same extent, system level approaches tend to be ad hoc and responsibility for controlling potential sources in manufacturing tends to be diffused or non-existent.

Learn more at:
http://www.semitracks.com/index.php/en/courses/public-courses/analysis/eos-in-manufacturing

Technical Tidbit

Sometimes, analysts ask whether they should purchase a Cold Cathode or a Schottky cathode field emission SEM. Although the Cold Cathode and Schottky cathode field emission systems both have excellent resolution, there are some differences between the two configurations. The Cold Cathode performance is achieved through a sharp tungsten tip. The sharp tip leads to a very high brightness, which in turn leads to higher resolution at low accelerating voltages. Cold Cathode Field Emission gives best images, but these sources are sensitive to gas atoms in the chamber, so vacuum must be better, which increases cost of system. The current can be unstable, so Cold Cathode Field Emission doesn't work well for certain applications like energy dispersive x-ray analysis. The low energy spread reduces chromatic aberration, leading to the highest quality images. The Schottky field emission uses thermal assistance. This reduces performance slightly but gives a more stable beam, making it a better choice for applications that require higher current. Some Schottky emitters use zirconium oxide coated tips to reduce the energy barrier at higher temperatures. Notice the lower probe diameter at higher beam currents for the Schottky emission configuration



The relationship between probe current and probe diameter for various electron sources

Upcoming Courses

[Failure and Yield Analysis](#)

June 7-10, 2011 – Singapore

[Semiconductor Reliability](#)

June 13-15, 2011 – Singapore

[Wafer Fab Processing](#)

June 14-17, 2011 – Singapore

[EOS in Manufacturing](#)

June 28, 2011 – Webinar

[ESD Design and Technology](#)

July 10-12, 2011 – Tel Aviv, Israel

Feedback

If you have a suggestion or a comment regarding our courses, online training, discussion forums, or reference materials, or if you wish to suggest a new course or location, please call us at 1-505-858-0454 or e-mail us at info@semitracks.com.

To submit questions to the Q&A section, inquire about an article, or suggest a topic you would like to see covered in the next newsletter, please contact Jeremy Henderson by email at jeremy.henderson@semitracks.com.

We are always looking for ways to enhance our courses and educational materials.

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For more information on Semitracks online training or public courses, visit our website!

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