News and views
for members of the
ESD Association

THRESHOLD™

Volume 17, No. 1 January/February 2001

News bits

New Texas officers

The Texas ESD Association has selected new officers and board members: Ray Bowman, Motorola, president; David Chestnut, C&M Consulting, vice president-membership; Gary Seale, Simco, vice president-education; Gene Hernandez, Bennett and Bennett, member at large; Bob Renker, Temple University, member at large; Steve Koehn, 3M, National Liaison, member at large; David Swenson, 3M, treasurer; Gary Sutorious, Motorola, secretary.

ESDA makes board appointments

The ESD Association has appointed Kay Adams, Tech-Wear, as secretary and Tom Diep, Texas Instruments, as treasurer.

Symposium planning underway

Set aside the dates of September 9-13 for the 23rd annual EOS/ESD Symposium. The location is Portland, Oregon. Watch future issues of *Threshold* and the ESDA web site for more details.

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ESD education in your own back yard

Not everyone can attend the annual EOS/ESD Symposium. However, this spring there are numerous close-to-home opportunities for learning about ESD as four local ESD organizations hold ESD tutorial programs to provide their members and others with background, information, and technology on ESD.

ESD Northwest kicks off the series on February 7 in Portland, OR. The Texas ESD Association holds a two day tutorial in Austin April 5-6. The Silicon Valley EOS/ESD Society holds its annual ESDiscovery in Santa Clara, CA on April 17, and the Midwest Chapter finishes up the series with a two day program on May 2-3 in Schaumburg, IL.

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Pacific Northwest Regional ESD Tutorial
February 7
Doubletree Hotel-Lloyd Center
Portland, OR
Co-sponsored by ESD Northwest and the ESD Association

ANSI/ESD S20.20 ESD Control Program Standard, Dave Leeson, Motorola
ESD Control in Cleanrooms, Julian Montoya, Intel
ESD Audit Measurements, Stephen Halperin, SHA/Prostat

Information and Registration: Contact ESD Association. Web sites: www.esda.org. Northwest ESD web site: www.esdnw.org

Texas Regional ESD Tutorial
April 5-6
3M Innovation Center
Austin, TX
Sponsored by the Texas ESD Association

Thursday, April 5

Basics of ESD, David E. Swenson 3M
ESD Auditing, David Chestnut, C & M Consulting

Friday, April 6

Using ANSI/ESD S20.20 for ESD Program Development, David E. Swenson, 3M
Panel Discussion on ESD Issues

Information and Registration: Steve Koehn, 3M Company, 6801 River place blvd, ms/143-4n-01, Austin, TX 78726-9000, PH: 512-984-3170, E-mail: sckoenh@mmm.com

From the Threshold chair

Striving for the advancement of theory and practice...

Does anybody recognize or remember the full text of the above headline?

It is part of the Association's mission statement that can be found on page 2 of every issue of *Threshold*.

Advancing the theory and practice of electrical overstress (EOS) and electrostatic discharge (ESD) avoidance is what the ESDA is all about.

Leo G. Henry

One of Threshold's functions is to provide you, the member, with relevant information that will help you to advance this knowledge. This is because there will always be a need to keep learning as new individuals become involved with ESD, new ESD issues are realized, and new solutions are found. Threshold, therefore, provides some direction as to where to go to facilitate this learning process. The newsletter comes to you filled with information about ESD, such as the articles in this issue on SiGe and the meaning of ohms per square. Also, we regularly include information on Association activities, such as the ESD Symposium and the ESD tutorials, that also serve as educational resources.

Now that we all know what we are striving for, we mention the fact that this is **your** newsletter. Please participate and help it remain a successful tool for advancing the theory and practice of EOS and ESD. The editor and I will be happy to publish your contributions. Please send articles, news, updates, letters to the editor, and other information to Mike Brandt (mtb@mrlweb. com).

Until next issue

LeoG

Threshold

THRESHOLD™ is published six times a year for the members of the ESD Association. The association is a not-for-profit corporation. It strives for the advancement of theory and practice of electrical overstress avoidance and of allied arts and sciences and the maintenance of a high professional standing among its members and others.

Threshold™ Publication Schedule

Issue	Deadlines
March/April	Feb. 1
May/June	April 1
July/August	June 1
September/October	Aug. 1
November/December	Oct. 1
January/February	Dec. 1

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Discover Portland, host for the 2001 Symposium

The Oregon Convention Center, Portland, OR, site of the 2001 EOS/ESD Symposium.
Photo courtesy of Portland Oregon Visitors Association

Portland, Oregon – City of Roses – City of Fountains – City of Bridges – River City – Rip City. It is a hub of international trade, the gateway to a natural wonderland, and the host to the 2001 EOS/ESD Symposium September 9-13.

Nestled in the heart of the Willamette Valley, Portland sits squarely between the Pacific Ocean (90 minutes by car) and the 10,000 plus foot tops of the Cascade Mountain Range (Mt. Hood is 1 hour by car).

You can literally go clamming at the beach during the day, have dinner in Portland that night, and go snow skiing in the mountains the next day. A 45-minute drive east from town on Interstate 84 places you smack dab in the middle of the **Columbia Gorge National Scenic Area**, a place of breathtaking beauty that includes 620-foot **Multnomah Falls**.

When you're not in a technical session, workshop, or tutorial, take time to enjoy our host city. In this "foot friendly" city, you will be intrigued and amused. Cafes, restaurants, bookstores, galleries and specialty stores are waiting around every corner. Words of wisdom from famous thinkers are carved in the brickwork under one's feet. Bronze sea lions and bear cubs frolic among award-winning architecture. Green-suited concierges known as "Portland Guides" walk through downtown streets day and night answering questions and helping with directions.

Pioneer Courthouse Square, a public plaza designed after the ancient Greek and Roman public squares, sits in the hub of downtown. Affectionately known as the "city's living room," Pioneer Courthouse Square brings together representatives from every possible social and cultural niche – a metro melting pot. On sunny summer days, the square hosts high-powered executives and purple-haired poets alike for "brown bag" concerts. If you finally tire of walking, "**MAX**," Tri-Met's light rail system, connects the Oregon Convention Center to downtown, the Rose Quarter, the Lloyd business and retail district, and outlying residential neighborhoods.

Dozens of parks in all shapes and sizes dot the entire city. One hundred acre **Washington Park** in the west hills above Portland encompasses the **International Rose Test Gardens** with more than 400 varieties of roses, the peaceful contemplation of the **Japanese Gardens** and the **Oregon Zoo** with its world-class elephant exhibit. Washington Park also provides a breathtaking panorama of Portland with Mt. Hood in the background.

Tom McCall Waterfront Park traces the west side of the **Willamette River** for two and one-half miles, and reverberates throughout the summer months with cultural, musical and gastronomic festivals. The river itself winds through the center of Portland like a bright blue ribbon, where tugboats, sailboats, historic sternwheelers, water skiers, rowers and salmon fisherman recreate.

If Portland sounds like a great place to hold a Symposium, start making your Symposium plans now. For more information on Portland, visit the web at www.pova.org

Some facts about Portland

Saturday Market is the largest continuously operating open-air crafts market in the US.

Powell's City of Books, occupying an entire city block, is the country's largest new-and-used book store.

Portlandia is the second largest hammered copper statue in the world (the Statue of Liberty is the first).

Portland's International Rose Test Garden is the oldest in the nation.

More Asian elephants (27 to date) have been born in Portland than in any other North American city.

Portland has more movie theaters and restaurants per capita than any other city in the United States.

Portland has more microbreweries and brew pubs than any other city in the nation.

Portland is the only U.S. city with an extinct volcano (Mount Tabor) within its city limits.

From the president

Y2K a boon for the Association

John Kinnear

The Y2K problem. We heard it over and over again at the start of last year. Would the start of the year 2000 be a disaster or just a big party? I also wondered what the new year would bring for the ESD Association. We began the year with some ideas and expectations, but would they be met?

I am glad to report that the past year was better for the ESD Association then I even imagined. I would like to take credit for it all, but the real credit goes to the many volunteers and companies that support the Association. The story of the Association in the year 2000 is really their story.

Symposium

Let's start with the just concluded 2000 Symposium. As 1999 general chair Tom Diep can tell you (with ears on), the 2000 Symposium had record attendance and a record number of paper submissions. If you missed the Symposium this year, you really missed a world-class event. Congratulations go to Koen Verhaege and his team for a wonderful event.

The Symposium tutorial program also set an attendance record. The tutorials went so well that extra tables and chairs were being brought in at the beginning of tutorials. My thanks go to Ginger Hansel and her team for the national tutorial program. Plus, a special thank you to Burt Unger who once again put together the right mix of topics.

Standards

The standards activity released several new documents this year and is about to release the update of the ESD Handbook as a companion document to ANSI/ESD 20.20 with the detail that you can't find in the standards. The most exciting standards occurrence was the US Department of Defense acceptance of the S20.20 standard for use within the military. My thanks go to Ron Gibson and his team for developing the S20.20 standard and all the standards that have been released this year.

20.20 certification

A new initiative that the Association undertook this year was providing the industry with a facility certification program so that a third party audit can be done for compliance to an ESD control program based on S20.20. Working with an accredited registrar, DNV, there is now a way to obtain a facility certification, which was announced in September at the Symposium. For more information on S20.20 certification, contact Association headquarters. Or, ask your ISO 9000 registrar to contact Association headquarters if you would like them to have the ability to certify your facility or your suppliers.

Outreach, local chapters

With all the interest in our Association, we have been asked to participate in other events by other organizations. This year, the Association presented sessions at NEPCON, Cleanrooms East, DISKCON and Cleanrooms/Datastor in Singapore.

There was even a new chapter in the Portland OR area. The Northwest chapter was recognized as a fully accredited chapter in May. This local chapter grew up quickly and has a good core group of people to start it out right.

Our web site grew this year and we have been getting more and more hits. Most of the hits to the site were for S20.20 downloads and for information on ESD. Information still seems to be the number one item people need. Look for a new member's area sometime this year.

These were just a few of the Association's accomplishments in 2000. I look forward to a new year and what it will bring.

Calendar of events

February 2001

ESDA Standards and Committee Meetings: February 2-6, Doubletree Hotel, Portland, OR, 315-339-6937, www.esda.org

Midwest ESD Chapter Meeting: February 7, Facility Tour, Tellabs Operations, Bolingbrook, IL, www.midwestesd.org

Pacific Northwest Regional ESD Tutorial: February 7, Doubletree Hotel-Lloyd Center, Portland, OR, 315-339-6937, www.esda.org

Silicon Valley EOS/ESD Society Membership Meeting: February 20, Ramada Inn, Sunnyvale, CA, www.esdsiva.org

March 2001

Midwest ESD Chapter Meeting: March 7, ESD/EMI Testing to IEC 1004-2, August Greidanus, Siemens Medical Systems, Bimbo's Restaurant, Palatine, IL, www.midwestesd.org

ESD Northwest Chapter Meeting: March 14, Nuclear and DC Ionization, Jim Curtis, Simco; INTEL, Hillsboro, OR, www.esdnw.org

Silicon Valley EOS/ESD Society Membership Meeting: March 15, Ramada Inn, Sunnyvale, CA, www.esdsiva.org

DISKCON Asia-Pacific: March 14-15, Singapore, www.idema.org

Northeast ESD Chapter Meeting: March 21, Corrosion Enhanced ESD Effects, John Franey, Bell Labs/ Lucent Technologies; HP-Ailgent Center, Burlington, MA, www.nechapteresda.org

April 2001

Texas Regional ESD Tutorial: April 5-6, 3M Innovation Center, Austin, TX, PH: 512-984-3170, Email: sckoenh@mmm.com

Lessons in electrostatics

Ohms per square what?

Gene Chase
ETS, Inc.

Is it ohms per square meter or ohms per square inch? Which is it? Actually, it is none of these, but "**ohms per square anything.**" However, this confusing term long has been used to describe the **Surface Resistivity (r)** of a material. Is it here to stay forever?

The ESD Association Glossary, ESD-ADV 1.0-1994 (1), describes **Surface Resistivity** as follows: "For an electric current flowing across a surface, the ratio of DC voltage drop per unit length to the surface current per width. In effect, the surface resistivity is the resistance between two opposite sides of a square and is independent of the size of the square or its dimensional units. Surface resistivity is expressed in ohms per square. When using a concentric ring fixture, resistivity is calculated by using the following expression, where D1 = outside diameter on an inner electrode, D2 = inside diameter of the outer electrode and R = measured resistance in ohms: (from EOS/ESD-S11.11 - 1993)(2)."

$$\text{Surface Resistivity } \rho_s = \left(\frac{2\pi}{\ln(\frac{D_1}{D_2})} \right) R$$

Some have asked, why use this allegedly ambiguous term and measurement? Can't we just use ohms? Because of the geometry of the EOS/ESD-S11.1 concentric ring electrode, the resistance is simply $\rho_s/10$ **ohms**. One could further argue, why not just always use this resistance result as **ohms**?

In order to answer these questions, we need to examine the history of **ohms per square**. For a number of years, **surface resistivity** was a pure number with no dimensions. Valdes (3) in 1954 wrote about the four-point probe method to make resistivity measurements on germanium transistors. However, all this early work, and later work by Uhlir (1955)(4) assumed a three-dimensional structure with one infinite dimension. Their work was expanded by Smits (5) in 1958 for two-dimensional structures. Smits defined a four-point probe method of measuring "**sheet resistivities.**" This work eventually became an industry standard for measuring the resistivity of diffused layers in semiconductors. Smits developed correction factors for measuring sheet resistivities on two-dimensional and circular samples using a four-point probe where the two outer probes source current and the two inner probes measure voltage. He found that this method was not only useful for measuring diffused surface layers, but was useful in obtaining "**body resistivities**" of thin samples. Yet in all this work **sheet resistivity** (ρ_s) had no dimensions, but was a pure number. Although Smits showed that body resistivity (ρ) was equal to sheet resistivity (ρ_s) times w, where w is the thin sample thickness, he did not assign the dimensions, **ohm-cm**, to this resistivity. The term he called "body resistivity," we now commonly call "volume resistivity" or "bulk resistivity." It is interesting to note that in Smit's work he never uses the term "sheet resistance." He developed the relationship that:

$$\text{Sheet Resistivity } \rho_s = \frac{V}{I}\left(\frac{\pi}{\ln 2}\right) = \frac{V}{I}(4.53224)$$

In 1962, Irvin (6) developed curves showing the **resistivity** in **ohm-cm**, versus impurity concentration of various doping levels in silicon. Here he defined the "**bulk resistivity**" as **ohm-cm**. The resistivity is again dimensioned as **ohm-cm**. There is no mention in this publication of sheet resistance or ohms per square.

In 1968, Berry, etal. (7) state that the resistance of a thin-film resistor is directly proportional to the resistivity, ρ, and inversely proportional to the thickness, **d**. They introduced the term "**sheet resistance (Rs)**" to define thin film resistor parameters as:

$$R_s = \left(\frac{\rho}{d}\right)$$

The authors further explain that the **sheet resistance** may be thought of as a material property since the film is essentially two-dimensional. Therefore, a simple thin film resistor consisting of a simple rectangle of length **l** (in the direction of the current) and the width **w** has a resistance of:

$$R = \left(\frac{\rho}{d}\right)\left(\frac{l}{W}\right)$$

or

$$R = R_s\left(\frac{l}{W}\right)$$

The authors claim that the term **(l/w)** is sometimes called the number of squares in the resistor, since it is equal to the number of squares of side **w** that can be superimposed on the resistor without overlapping. They assert that the term "squares" is a pure number, having no dimensions. The author's state that the sheet resistance has the unit of ohms, but it is convenient to refer to it as "**ohms per square**" since the sheet resistance produces the resistance of the resistor when multiplied by the number of squares.

They go on to say that the concept can be broadened to include any arbitrarily shaped resistor by calling the quantity **Rd/r** the effective number of squares. The authors expand on Smit's four-point probe technique and introduce new cor-

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The silicon-germanium revolution and ESD

Steven H. Voldman
IBM Communications Research and Development Center
Essex Junction, VT

Introduction

A new revolution in semiconductor technology is underway with the acceptance of silicon germanium (SiGe) technology and its penetration of the high-speed wired communications, wireless, optical interconnect, and test equipment sectors.

Announcements appear daily in the electronic news and on the Internet of the new applications for SiGe technology. The application explosion is widespread. New opportunities exist in 10 to 40 Gbit/sec Ethernet to SONET influencing our future in wired high speed data transmission at speeds never anticipated. New high-speed scopes will expand our ability to test and investigate high-speed phenomenon and test faster semiconductor devices. LNAs, VCOs, pre-amplifiers, power amplifiers, remote sensing, networking, SONET, RF testers, cellular phones, satellite communications—it is a new world in communications with SiGe opening the door to faster devices not achievable in standard CMOS or homojunction BiCMOS technology.

Steven H. Voldman

Looking in from the outside, it may be difficult to understand the revolution that is about to begin. As an insider, let me pose some questions and provide some answers that may provide some insight into this new technology.

Asking some questions

What is so special about silicon germanium? Where did this technology come from? Why, all of a sudden, is SiGe an issue? Why is it being more accepted today? How does it work? How does it compare to GaAs technology? What are some of the pros and cons? Why is it of interest as an ESD engineer?

What makes silicon germanium so special is that it is a heterojunction. The importance of heterojunctions to today's society was acknowledged with the 2000 Nobel Prize for physics. Herbert Kroemer, co-recipient of the Nobel Prize, was a leading developer in quantifying the heterojunction bipolar transistor (HBT) device. Why is this valuable? Heterojunctions, as opposed to homojunctions, opened a new field called "bandgap engineering" for semiconductor device designers.

But why SiGe?

Where did it come from? In its early development, silicon germanium was envisioned as a follow-on technology, replace the bipolar transistor as silicon homojunction transistors achieved their ultimate scaling limits, analogous to SOI is to replace bulk CMOS technology. The objective was to develop these high-speed SiGe transistors for replacement of the conventional high-speed Si homo-junction transistors in bipolar SRAM memory chips for large mainframe machines. However, the mainframes migrated to CMOS technology leaving this new transistor without a mainstream home. The strategic shift of integrating the SiGe transistor into a BiCMOS technology and rapid growth of the telecommunications industry, high speed communications and need for faster devices opened a new door for mainstream development.

Why is SiGe being so easily accepted? First, the SiGe transistor can be built on

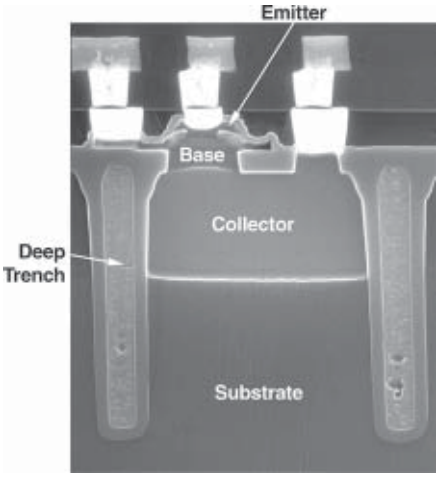

Figure 1: Cross section of a SiGe heterojunction bipolar transistor.

any conventional CMOS technology. This allows for integration with standard CMOS circuits, and compatibility with the environment of CMOS foundries. Second, it is a technology that can be placed on a CMOS technology without many additional tools. Third, it is scalable – faster transistors can be created each generation. Transistor speeds are rapidly moving from 10 GHz toward 100 GHz devices. Is there a limit? Yes, the Johnson limit that states for a given breakdown voltage, there is an ultimate speed of the transistor. However, bandgap engineering and new innovation will keep the SiGe HBT moving faster despite physical boundaries.

How does SiGe compare to GaAs technology? GaAs has many material advantages, but the limitation is that one cannot grow a native oxide on GaAs. This impedes the ability to integrate a GaAs high-speed device with CMOS technology. SiGe heterojunction bipolar transistors (HBT), on the other hand, have been integrated with mainstream advanced CMOS development, providing the advantages of SiGe technology for analog and RF circuitry while maintaining the

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SiGe revolution

CMOS technology base for digital logic circuitry.

SiGe transistors

What do the transistors look like? See Figure 1.

It is a transistor with a unique base region! Epitaxial deposition of silicon germanium alloy film, which can in principle be an atomically abrupt interface, avoids limitations of Gaussian profiles. Using UHV/CVD processing, SiGe is deposited in the base region over single-crystal silicon and the shallow trench isolation (STI) structure. The Ge concentration is varied during the film deposition process for profile and device optimization. A window is formed over the single-crystal intrinsic SiGe base to form the n-type polysilicon emitter. Interconnection to the emitter, base and collector is defined by tungsten (W) local interconnects, dielectrics, tungsten contacts, and aluminum interconnects used in base CMOS technology. The beauty of this structure is that definition of trench isolation has been well developed for generations in Bipolar SRAM development, CMOS trench DRAMs, and other technologies. Secondly, it takes advantage of STI isolation providing planarity. Third, it takes advantage of local interconnects wiring, W studs, and aluminum or even copper interconnects; anything done in conventional CMOS can be utilized. A fourth advantage is that the epitaxial film can be built and scaled on a number of technology generations!

The impact for ESD

What does all this mean for an ESD engineer? First, the proliferation of SiGe based products will be widespread in a number of new application spaces. Understanding the SiGe device and ESD device physics will be important in the future. Second, SiGe devices will be used in high-speed RF applications where issues of ESD products are nontrivial. Noise, loading, linearity, gain characteristic degradation, and noise figure will be an issue for ESD designers trying to protect RF circuits. It will impact which ESD devices will be suitable in the future. Third RF product ESD sensitivity may require new procedures and standards as well as creating new ESD issues in manufacturing, tooling, handling, shipping, and in the field.

What are some of the ESD advantages of SiGe devices and SiGe technology? CMOS ESD solutions can still be used for ESD protection of SiGe technology on a number of product pins. Conventional CMOS ESD power clamps can still be utilized. BiCMOS technologies have low noise high quality passives that are useful for RF applications. Then there is the SiGe HBT npn and its derivative passive elements. Can you use that? Why not!

Figure 2 shows one of the first TLP measurements of a SiGe HBT device. What are some unique features? First the It1 is lower than It2! Second, because of the high doping in the base region, heterojunctions provide good current uniformity in the base compared to Si homojunction transistors. Third, SiGe HBTs are fast. Fourth, SiGe HBT devices have high current gain.

Which is better for ESD, SiGe HBT devices or Si bipolar junction transistor (BJT) devices? Our measurements show that SiGe HBT devices are as ESD robust as or even superior to Si BJT where the Si BJT devices are identically designed. From the first Wunsch Bell curve results ever reported (Figure 3), it is evident that there are advantages at shorter pulse widths.

The Silicon Germanium Revolution has begun. Expect to see growth in this area!

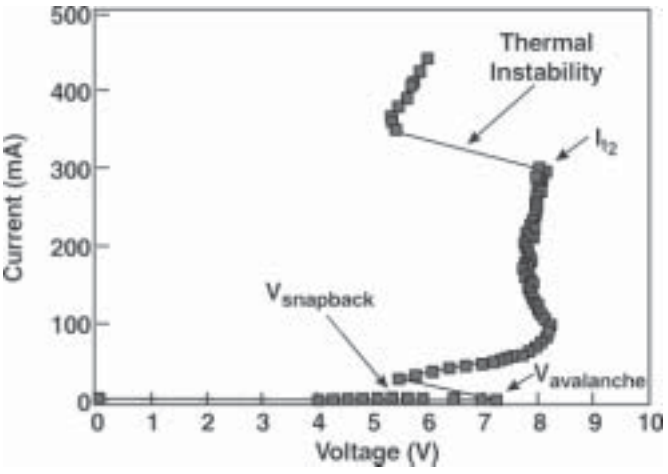

Figure 2: TLP I-V characteristic of a SiGe HBT device in collector-emitter configuration for 50 ns pulse width (0.32 x 20 µm emitter width).

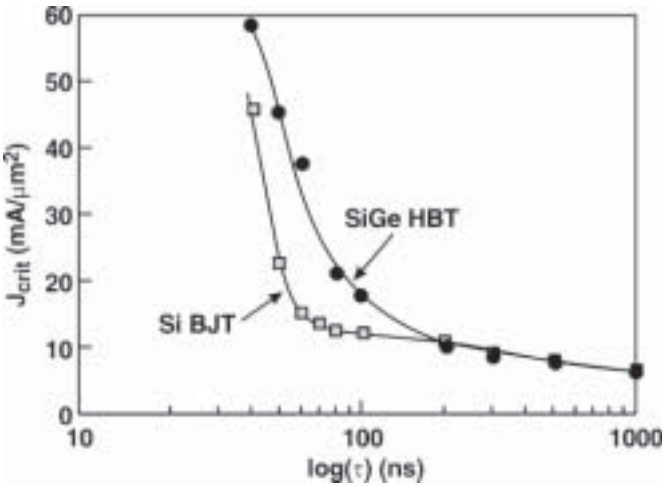

Figure 3: Wunsch-Bell J_{crit} vs. plot SiGe HBT and Si BJT.

Exam time in Anaheim

Lou Patterson
K&L Services

The professional certification efforts at the 2000 EOS/ESD Symposium were impressively successful. Increasingly, ESD professionals and companies involved with ESD control concerns are recognizing the importance of ESD professional certification. The fact that 64 engineers and technicians took part in the NARTE certification exams during the Symposium shows the emphasis that is now being placed on this important area.

This year we had an equal number of technicians and engineers taking the tests. Of the 32 persons taking the engineering test, 28 passed the test. The technician candidates obtained even a better record, with 30 of 32 people successfully completing the exams. That is an 87.5% pass rate for the engineers and a 93.8% pass rate for the technicians.

We still experienced some growing pains on the test contents, but they are improving and we expect to be in much better shape by next year.

Several Symposium tutorials were identified as good preparatory classes for the certification exams. The candidates who took the tests indicated these classes helped them in their final preparations. The final two classes specifically targeted toward the exams were highly attended (Standards and Procedures – 120 attendees, and Engineering Calculations – 60 attendees), and were identified as particularly helpful for taking the tests.

We continue to encourage all ESD professionals to obtain, and maintain, their certification. Designed to foster technical competency and technological excellence, professional ESD certification benefits both individuals and the industry.

In 2001, the certification exams again will be held in conjunction with the Symposium. The date is September 14. We strongly encourage our membership to take part in this important program.

Preparation, reference materials, laptops and concentration paid off for 58 individuals who passed the ESDC certification exams in Anaheim.

58 pass ESDC certification tests

Congratulations to the following individuals for successfully passing their NARTE certification tests. Remember that certifications are only issued after all the required paperwork has been submitted and approved. So make sure you get all your documentation in to NARTE right away.

Technicians:

Larry Casalinuova
Gary E. Cooper
John D. Dollar
Raymond F. Fitzsimmons
Joseph M. Fortin
Vineshwar K. Goundar
David S. Harper
John Hart
Carlos Herrera
Omar Ishar
Leroy H. Jackson
Rodney J. Jacobs
Michael B. Johnson
Chee Seng Kaam
Mary M. Kreisle
Hiroshi Kurosaki
Charles A. Lawson
Harris Liu
Jimmy H. Liu
Doug McLaughlin
Randy J. Monohan
David J. O'Reilly
Chen Zi Ping
John J. Skordynski
Carroll G. Slaughter
Jack C. Smiley
Thomad Strickland
Pez Ya Tan
Brian P. Villinsky
David Willis
Deamer Wu

Engineers

Ali Reza Abdollahpour
Frank C. Angel
Yun Hsiang Chen
Yung-Sheng Chen
Chunghan Cheng
William N. Edwards
Mel Gannon
Angelica Gomez
Wei Guan
Dirk M. Kubernus
Patrick Lim
Yu-Chang Liu
Salvador Llobet
Jonathan M. Mis
Julian A. Montoya
Bi Mu-Chiang
Richard M. O'Hanlon
Steven L. Poe
Harrell Dale Reynolds PE
Paul Shin
Inderjit Singh
Walter J. Sparzak
Yao-Cheung Tsai
Scott T. Ward
Kevin Wu
Tren-Chi Wu
Wu Lang Yeh
Paul C. Zinger

Symposium tutorials deliver education

With thousands of persons attending previous seminars and tutorials, you would think that we would be running short of prospective students. But, the upward trend in attendance demonstrates a continuing need for education. The problems of ESD don't go away. More and more companies are discovering the problem. There are new people becoming involved in ESD for the first time. The demand for education is there.

Five years have passed since Burt Unger first penned those words in *Threshold* to describe the 1995 EOS/ESD Symposium tutorial program. Five years and five tutorial programs later and the attendance trend is still on an upward slope. The demand for education is still there.

Tutorials set records

Like the total Symposium, the tutorials set numerous records in 2000. Twenty-five sessions were spread over three days. The topics ranged from the old standbys such as ESD Basics to totally new sessions like ANSI/ESD 20.20, RF Protection, TLP Testing, and Cleanroom Ionization.

Programmed along four distinct tracks (Factory, System and Technical, Design, Magnetic Recording), the sessions were packed. Ten tutorials had more than 100 attendees with ESD Basics having a record 163 and the new RF On-Chip Protection tutorial having 159 attendees.

Certification preparation

Eleven sessions were designated as preparatory tutorials for the ESD certification examinations. Two of the sessions, *ESD Standards and Procedures* and *Electrostatic Calculations*, have been developed specifically to help attendees prepare for the exams. The tutorials must have helped because 58 persons passed the exams on Friday.

Attendees comment

Most tutorial attendees seem satisfied with the educational materials provided. Comments such as the following are typical:

Excellent and very informative…well organized

Good material...hard to get all at one place at one time

While the 2001 Symposium in Portland is several months away, Unger, who chairs the tutorial program, is already hard at work to maintain the high level of education that attendees expect. Taking attendee evaluations into account, Unger says, "As we prepare for the 2001 program, we'll review the input from attendees and examine the educational needs of our prospective audience to develop a tutorial program that complements the Symposium's technical papers and workshops. We will continue to improve, modify, and enhance this program that has become an important part of the educational mission of the Association."

Symposium tutorials attract attendees anxious to expand their knowledge of ESD. Don Pierce, Ph.D. (left) presented the session on Electrostatic Calculations for the ESD Engineer*, one of the certification exam preparatory tutorials. A packed audience listens as Lou Patterson provides an overview of* ESD Standards and Procedures*, another of the certification exam preparatory tutorials.*

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Ohms per square what?

rection factors for the size of their substrate. It turns out that the four-point probe is a useful tool to check the uniformity of thin-film resistors.

The term "**sheet resistance**" is used not only to define ESD control materials, but also to define resistive seas and overcoats of all types, including the coatings on cathode ray tube (CRT) monitor. It is also used to describe the resistance of the semi-transparent layer that composes one terminal of a liquid crystal display (LCD). The term continues to be used to define the resistance of both thick and thin-film resistors. In a notable book on the physics of semiconductors by Sze (8) in 1981, the term **sheet resistance** is not found to describe the characteristics of semiconductors. Only the term **resistivity** is used.

So now you know where the dimension "**ohms per square**" apparently originated. It appears that we are stuck with this term unless the authors of the ESD Association Glossary decide to redefine it and use only the dimensions **ohms** and **ohm-cm** for surface and body (volume or bulk) resistivity respectively.

Therefore, it would seem reasonable that **surface resistivity** should always be measured in **ohms** and **volume resistivity** in **ohm-cm**, as Jonassen (9) has argued for a number of years.

Maybe we should leave the term **sheet resistance** and **ohms per square** to the thick and thin film resistors and hybrid integrated circuit people, where it makes some sense to them and stick to using **ohms**.

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