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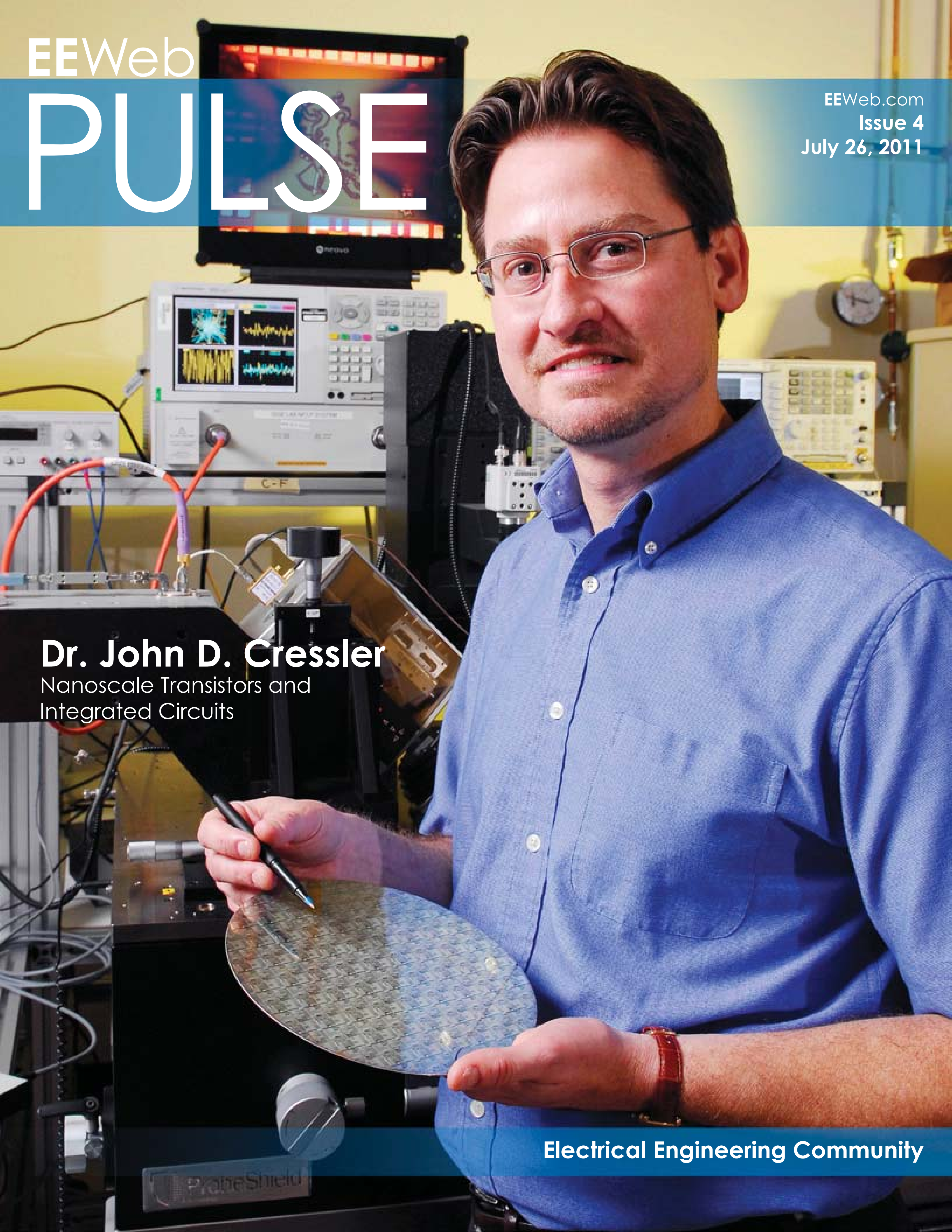

Dr. John D. Cressler

Nanoscale Transistors and Integrated Circuits

Electrical Engineering Community

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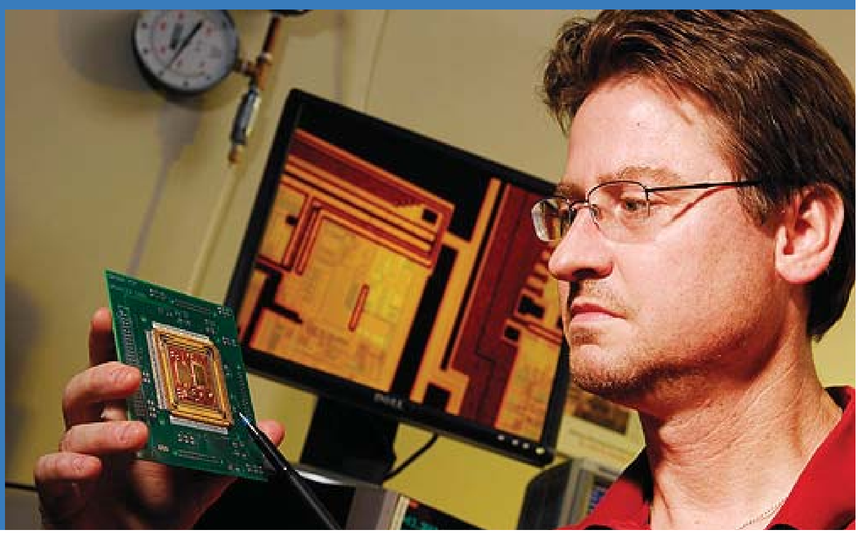
Nanoscale Transistors and Integrated Circuits

Dr. John D. Cressler - Georgia Tech. School of Electrical and Computer Engineering



How did you get into electronics/engineering and when did you start?

I had the great fortune as a junior at Roswell high school to take Calculus with Dr. Don Dorminy. Besides being a terrific teacher with a flare for the dramatic, Doc D helped me connect, for the first time really, the beautiful linkage between mathematics and physics. It resonated, and this turned out to be a tipping point in my life. 1978. After high school I attended Georgia Tech, majoring in physics. I loved it. During my sophomore year I began co-oping at IBM in the Research Triangle in North Carolina, working in a small R&D group doing ... microelectronics. Interestingly enough, microelectronics (read: all things transistor) turns out to be a great blend of physics and EE. I was hooked! I decided that I would stay a physics major, but take all of my electives in EE (admittedly not the easy path, but it served me very well), and over the next seven quarters I alternated between doing transistor R&D at IBM and taking classes in EE and physics aimed at developing the needed background. My career was set. When I graduated with my BS from Tech (1984), I took my dream job at IBM Research, in Yorktown Heights, NY, working on transistors and their use in novel types of electronic systems. IBM sent me back for my PhD (and paid my way!) at Columbia University in New York City. I finished in 1990. Two years later, on a whim really (read: another tipping point), I took a night time teaching job at a local university in Danbury, Connecticut (Calculus no less!), and literally from the very first day I knew I wanted to be a professor. I get to teach, work with and help train bright young folks, and also continue my research. Best job on the planet. I left IBM to join the EE faculty at Auburn University in 1992, and joined Georgia Tech in 2002. The rest is history.

What are your favorite hardware tools that you use?

My team specializes in the understanding, design, and measurement of game-changing novel nanoscale transistors, and integrated circuits from built them, including silicon-germanium (SiGe) heterojunction bipolar transistors (HBTs) (a mouth full!). We can measure scattering parameters on such devices to 67 GHz, tuned noise parameters to 40 GHz, and tuned load-pull (distortion) characteristics up to 40 GHz. All require very sophisticated (and expensive) instrumentation. In addition, we have several specialty instruments, one of which enables us to measure transistors and circuits running operating down to 4K, just above absolute zero. We used this instrument to set the world transistor speed record in SiGe transistors a few years back. It was operating with an extrapolated maximum power gain frequency above 600 GHz at 4.5K. This requires (clever) use of liquid helium – and a little luck!

What are your favorite software tools that you use?

To design our circuits we use the Cadence Design Suite for simulating, laying-out and checking our circuit designs prior to fabrication. For understanding the physics of our transistors we use Synopsis TCAD tools for building a virtual 3D transistor within the computer, simulating its physics, and then comparing those results to actual measurements to tease out information on what is actually going on.

What is on your bookshelf?

For my personal reading, it is novels all the way. Recent reads include "*A Visit from the Good Squad*," by Jennifer Egan, "*The History of Love*," by Nicole Krauss, and Colum McCann's, "*Let the Great World Spin.*" All were wonderful reads! Engineers MUST read non-technical books to be well rounded. I enjoy writing as well, and for those interested, you might check out my most recent book (shameless plug alert!), "*Silicon Earth: Introduction to the Microelectronics and Nanotechnology Revolution.*" It is intended to introduce non-specialists to the in's and out's of micro/nanotechnology. A fun read. Check it out on my web site. You might also see my TED talk on this topic (also on my website).

Do you have any tricks up your sleeve?

I tell my students to trust their intuition. Then back it up with hard evidence. I also tell them to never discount data that looks crazy or makes no sense at first glance. Most stand ready to toss such data in the trash, but our greatest discoveries usually turn up by chasing crazy data down the rabbit hole.

What has been your favorite project?

On the technical side, I think the NASA project described in the recent press release has been my favorite. We took some basic physics (SiGe HBTs should work well at extremely cold temperatures and in a harsh radiation environment), sold NASA on a vision to develop SiGe technology for such "extreme environments," and ran with it. We've had a ton of fun and the story is just at the beginning. What we are doing has the chance to influence a great many things in the way space missions are designed and carried out. That's exciting! We presently have some of our designs riding on the International Space Station.

> **Okay, okay—it did indeed have a protective plastic cover that said "DANGER, DON'T REMOVE" on it.**

I consider my principal vocation to be teaching, and I had a truly gratifying experience this past year. I always wanted to introduce a course for non-ECE students that assumed nothing but high school background, and yet would educate folks about the many miracles being created in microelectronics and nanotechnology. Miracles that are changing the way our world works. I wrote a book to go with it (see "Silicon Earth" above) and the course has really worked very, very well. I do the technical piece (how transistors work, where they came from), but also discuss societal impact issues (e.g., are social media a good thing?), and we do team "widget deconstruction" projects where we pull apart ubiquitous pieces of technology and see how they actually work (LCD TV, iPOD, GPS, etc.). A ton of fun!

Do you have any note-worthy engineering experiences?

Here's a fun one. "*Smoking a Device.*" One of my favorite childhood books was Hans and Margret Rey's 1941 "*Curious George*," about a cute little monkey named George who always seemed to get into trouble just because he was overly curious about things. Well, my name's not George, but on the first week on my new co-op job at IBM in Research Triangle Park, NC, way back when, I pulled a George. Yep, a mighty-green, still-wet-behind-the-ears, second year undergraduate co-op student from Georgia Tech, having just been trained to use a tungsten needle probe to contact and measure his first semiconductor device (a MOSFET), decided it would be cool to see just how much voltage his tiny little device could actually handle. In those dark ages we used something called a ``curve tracer'' for such measurements; basically just a fancy variable voltage/current source and meter. On the front of the curve tracer was a switch that would allow one to remove the current compliance limit on such a measurement (okay, okay — it did indeed have a protective plastic cover that said ``DANGER, DON'T REMOVE'' on it). Just for fun, I intentionally defeated the compliance protection and proceeded to ramp up said voltage on my device. I crossed the suspected breakdown voltage and just kept on going. Imagine my shock when I smelled something funny, glanced over at my probe station, and saw a small but clearly visible mushroom cloud of smoke rising from my device. Aghast, I raced to look into my microscope at the carnage, and to my horror, all I saw were peeled back, melted tungsten probes (melting point = 6,192 F), and underneath them, an ugly crater in the surface of my silicon wafer (melting point = 2,577 F) which said MOSFET used to call home. Alas, Mr. MOSFET was no more. SMOKED! Moral for George: In the absence of some mechanism to limit the current flow, breakdown in semiconductors will try VERY hard to reach infinite current. The IR drop associated with this now very large current will produce a massive temperature rise that that will quickly grow to surface-of-the-sun like temperatures! Not a good thing. To all you budding device engineers — you haven't lived until you have smoked your first device! Give it a try!

What are you currently working on?

For something technical, see "favorite project" above. How's this for non-technical? I am actually working on my first novel, a love story set in mid-14th century Muslim Spain, in the Alhambra Palace in Granada. Fascinating era. I'm trying to bring it alive. I just finished the first draft and am loving every minute of it. Stay tuned! ■