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Peering into the Nanoscale

JL: How did you decide to get involved in nanoscience & nanotechnology research? Did you know that you wanted to do something like this at an early age? Did you start your work here as a IBM post-doc and how did that transpire?

Dr. Haight: I became interested in science at an early age. I was fascinated by the space program, the solar system and the universe at large. I built my first Newtonian reflector telescope when I was 11 and spent a lot of nights looking at the cosmos. I went to college for astronomy and worked on the electronics for the university's radio telescope in Lake George, NY. When the program was shut down by the university I moved into physics. A lot of my graduate thesis work was carried out at **Bell Laboratories** in Murray Hill, NJ on ion scattering studies of surfaces. When I graduated with my PhD I continued on as a post-doctoral fellow at **Bell Laboratories** in Holmdel, NJ where I learned about ultrafast lasers and we carried out the first experiments using high harmonic photoelectron spectroscopy to study electron dynamics at indium phosphide and gallium arsenide surfaces. I then joined **IBM's TJ Watson Research Center** in Yorktown Hts., NY in 1985 where I continued studies of electron dynamics at semiconductor and metal surfaces as a research staff member. During my time here at **IBM** I have studied metal, semiconductor and organic materials using ultrafast laser techniques and more recently I carried out the first photoelectron spectroscopy experiments on single Si, Ge and ZnO nanowires.[1] I also built, with two other colleagues, the first commercial tool to repair photomasks for lithography using femtosecond lasers. Most recently I am using the spectroscopic techniques I have developed to study earth abundant thin film photovoltaic materials.

JL: You recently told me about the, exciting, forthcoming Krishna P. Singh Center for Nanotechnology at the University of Pennsylvania (to be completed in 2013); and I've noticed at least a half dozen similar research facilities as I travel around the U.S. and Canada. These are extremely expensive bets on the future of nanoscience and nanotechnology. Could you comment on that?

Dr. Haight: There are numerous nanotechnology centers and almost every large research university in the U.S. and the world at large has such a center. In addition there are centers at the **DoE labs** such as the **Center for Functional Nanomaterials** at **Brookhaven National Lab** and the **Center for Integrated Nano Technologies** at **Los Alamos National Lab**, to name a few. In addition **IBM** and other IC (integrated circuit) manufacturers are already producing chips with nanoscale features. For example, generations of ever smaller ICs are denoted by their gate lengths in CMOS (complementary metal-oxide-semiconductor) devices. So when we talk about the 22 nm node in IC manufacturing we are describing the gate length in that device, so as you can see we are already manufacturing things at the nanoscale at a massive level.

JL: Nanoscience & nanotechnology is a multidisciplinary, fast-moving area of research. One aspect that has caught my eye is nano-biomedical research and especially new nano-drug delivery systems and even nano-diagnostic systems. I believe that Columbia University's Nanoscience Center is doing research in this area. Please tell us more.

Dr. Haight: Since biology distills down to structures at the nanoscale such as DNA, viruses and bioactive molecules, studies at the nano level are critical to the fundamental understanding of diseases. Therefore, pharmaceutical companies must work at the nanoscale and, just as their material science bretheren, utilize instrumentation that can reveal the science of the nanoscale materials they are studying.

JL: We (non-scientists) keep hearing about: nanotubes,[2] quantum dot nanomaterials, carbon-nano-balls and of course nanotechnology will be playing an incredible developmental role with the advent of quantum computers. Can you help us get our minds around these fast developing areas of research?

Dr. Haight: Quantum computers are only one area that utilizes science at the nanoscale. At **IBM** there is a large effort to make ICs from carbon nanotubes instead of silicon so that scaling to ever smaller dimensions becomes possible. In order to integrate devices for conventional and quantum computers, ever higher densities requires smaller devices. As I mentioned silicon-based devices already have components with nanoscale dimensions and this will continue for years to come. Since silicon devices can be reduced in size only so much, follow-on technologies such as carbon nanotubes, electron spin based devices and more must be exploited. Again this means developing and studying materials on the nanoscale.

JL: Your recent book, "Handbook of Instrumentation and Techniques for Semiconductor Nanostructure Research," 2 vols., (available, e-version and print), World Scientific Publishing, 2011, deals with peering into nanoscale materials, etc. I find it so amazing that researchers are able to actually view these nano materials and manipulate them. I remember seeing photos of IBM researchers actually moving atoms around at will. Even for professionals this must be very exhilarating work. Please give us some of your insights here.

Dr. Haight: The work is exhilarating because we are "seeing" science at atomic dimensions and the knowledge we gain permits us to study and manipulate nature to our needs at these incredibly small dimensions. Presently available instrumentation and new advances to come will continue to allow us to peer into nanoscale systems that will reveal new science.

JL: Could you provide us with a glimpse of that "new science" — a scientific revelation that is likely to appear from the research labs, ten years "down the road?"

Dr. Haight: Right now my efforts are focused on renewable energy research, specifically in the area of thin film photovoltaics. I believe that within ten years we will see significant scientific advances in areas of critical concern to society. New earth abundant materials will be used to generate power from the sun and will utilize new materials, many engineered at the nanoscale to guide and concentrate light for terawatt-scale[3] power generation. I believe this is some of the most critically important scientific and engineering work that will blossom within the next 10-20 years.

JL: Many thanks on behalf of Against the Grain readers for taking the time to talk with us.

Endnotes

1. "A few billionths of a meter in diameter," *MIT news.*
2. "Nanometer-scale drinking straw," *MIT news.*
3. Example, 3.34 TW (terawatts) = "total gas and electric power consumption of the U.S. in 2005," Wikipedia.