**An Autobiographical sketch**

**Jay Gupta**
Winner, 2007 ACIPA Outstanding Young Physicist Prize

**Current research interests**

Information technology has been fueled by the miniaturization of components such as silicon transistors in integrated circuits and magnetic bits in hard disk drives. Future miniaturization is expected to be limited by material, circuit, and system architecture constraints well before fundamental physical limits are reached. An understanding of materials and structures at the nanometer scale is needed continue progress in conventional technologies and to explore possible alternatives before limits have been reached.

My research program is focused on exploring the evolution of electronic, magnetic and optical properties in nanometer-scale structures. My interest in this general theme has developed over the years, starting from quantum mechanics courses I took as an undergraduate at UIUC, continuing on to my PhD thesis at UCSB and then on to my post-doctoral research at IBM. As an Assistant Professor at Ohio State, I have set up a lab which is developing new techniques to build and study the properties of nanostructures as their size is varied from one to thousands of atoms. The scanning tunneling microscope (STM) is a versatile tool that can be used to image surfaces with atomic resolution, manipulate single atoms on surfaces to build nanostructures, and probe the properties of nanostructures (e.g. Fig. 1). My lab is developing new methods to extend these capabilities by combining STM with optics. These efforts draw upon the skill set I developed as a graduate student at UCSB, where I utilized optics to study magnetism in semiconductors, and as a post-doc at IBM, where I learned the technique of STM.

The following sections illustrate some of my work and experiences. I've been incredibly fortunate throughout to have the support of my parents, Surendra and Karen, and my sister Amanda. As I go forward, I'm blessed to have the support of my wife Beth. The strong foundation of friends and family I'm surrounded with is indispensable.

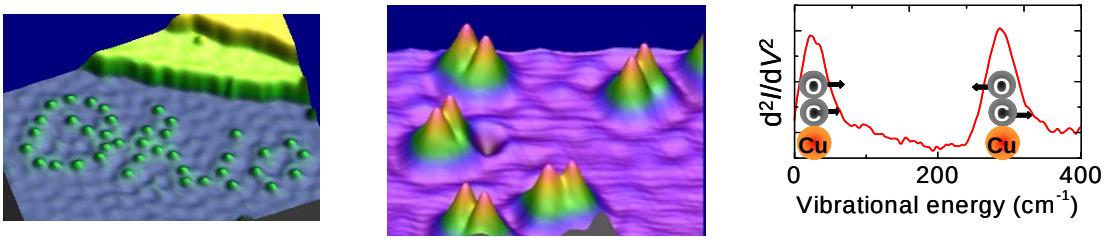


**Fig. 1** STM studies of single atoms and molecules. *Left:* Individual cobalt atoms are positioned with the STM on a copper surface. In this way, nanostructures can be built with atomic precision. *Middle:* STM image of single azobenzene molecules. The surface chemistry of such molecules can be studied with STM. *Right:* STM tunneling spectroscopy of a single carbon monoxide molecule on a copper surface. The two peaks indicate different vibrational modes of the molecule.

**K-12 in St. Louis, MO (1981-1991)**

It's always interesting to trace our roots back and see the choices and events which ended up having a profound impact on our lives. I can trace my interest in science back to the 3rd grade, where I recall looking at the dispersion of sunlight through a prism. While I don't recall ever having a specific profession in mind for 'when I grow up', I've since operated under the assumption that I would be a scientist of some sort. In addition to the questions that science addresses, I've always enjoyed the everyday activities of science: making plots, writing things down in a lab book, and doing calculations.

My interest in physics was fueled by Dr. David Lay, who was my teacher for a two-year AP physics course in high school. Dr. Lay was (almost) always very patient with our smart-alecky behavior, and always came up with really interesting experiments and topics for the course ranging from Newton's laws to digital electronics. Given his research background in particle physics, Dr. Lay was never content just to teach standard text-book physics.

**Undergraduate studies at UIUC (1991-1996)**

When I started at UIUC, I hadn't formally committed to a major. I knew I was interested in science, so I took the standard array of math and science courses including chemistry, math and physics. Looking back, I'm amazed at how voracious I was in my course-work. I've always loved school, and I really immersed myself in classes during my entire time at UIUC. I ended up graduating with >190 hours of coursework, which was enough for B.S. degrees in physics and chemistry. While these subjects were my primary interest, I was also interested in and took electives in Archaeology, Geology, English and History. At this time, undergraduate research was just becoming a priority in the U.S., and my research

The UIUC arboretum, which was completed during my stay there, and was one of my favorite places to visit at night.

experience was actually quite minimal. Fortunately my physics and chemistry lab courses exposed me to a variety of experimental techniques.

**Graduate research at UCSB (1996-2002)**

In applying for graduate schools, I had wanted to live in California, and was hoping to go to Stanford or Berkeley (but wasn't accepted). I had also happened across the brochure for UCSB and decided to apply even though I had never heard of the school. It turns out that UCSB had undergone a remarkable growth in the last 20 years, becoming a top 15 university (unbeknownst to me). I was so impressed by the environment at UCSB that I followed my instinct and decided to go there, instead of better-known (to me at least) schools like Michigan and Cornell where I had also been accepted. I was fortunate to be supported as a research assistant from the beginning by Prof. David Awschalom at UCSB. David had started at UCSB 5 years earlier after being a staff researcher at IBM. David had assembled a talented group of graduate students, and I liked the environment in the group so I started research and never looked back. My PhD thesis was focused on measuring and manipulating electron spins in semiconductors. This work fits within the context of "spintronics", which is an alternative paradigm for electronics in which the spin of electrons is used for computation and information processing. Spin-based electronics has attracted considerable interest in the physics community within the last 10 years, and the Awschalom group's measurements of spin in semiconductors is one of the foundations for that interest.

University of California, Santa Barbara

**Postdoctoral research at IBM's Almaden Research Center**

In looking for a postdoctoral position, I was driven by a desire to learn new skills. At UCSB I felt I had a good handle on optical techniques, and had used ultrafast lasers extensively. I applied to a variety of groups in physics and chemistry departments that specialized in different techniques from what I knew. Of these, Don Eigler's group at IBM's Almaden research center really stood out to me. Don is a true physics pioneer who first developed low-temperature scanning tunneling microscopy to manipulate single atoms. Don's group was small, consisting at the time of Andreas Heinrich and Chris Lutz. I consider both to be excellent scientists and good friends. From my first visit, I could tell that these people were really enjoying themselves. While the breadth of basic research at IBM had been curtailed in the early

IBM's Almaden Research Center in San Jose, California

1990s, my immediate environment at IBM-Almaden was first-rate in terms of the quality of people there, and the freedom to pursue curiosity-driven research. My research applied low-temperature STM to study the electronic, magnetic and physical properties of individual atoms and molecules. In our most enjoyable project, we constructed domino-like arrangements of CO molecules called 'molecule cascades' in which CO quantum tunnels to successive sites along the cascade. A molecule such as CO is usually considered too heavy to exhibit quantum tunneling, but by building atomically precise molecule cascades, the potential barrier can be tuned to allow tunneling.

**Final Comments**

I consider myself to be extraordinarily lucky in life, but also believe that we make our own luck. As I look back on the choices that have brought me to the present, two things warrant mention:

1) I've always enjoyed the day-to-day activities of my positions, be it in class or in research. Hard work is never a chore if you really enjoy what you're doing, AND you only do what you enjoy.

2) I've primarily relied on instinct in making choices. Compared to most of my peers, I planned relatively little, and am quite oblivious of reputation, rankings and prestige. Instinct has always been my most reliable guide, and I rely on it to this day.

My final thanks go to the ACIPA for presenting me with the Outstanding Young Physicist Prize.

Jay Gupta is currently an assistant professor of Physics at The Ohio State University. He holds a BS cum laude in Chemistry and a BS cum laude in Physics with highest distinction from the University of Illinois at Urbana-Champaign obtained in 1996. He obtained his MA in Physics in 1999 and his PhD in Physics in 2002 from the University of California at Santa Barabara.