NEMS and All That Jazz... Q & A with Sumita Pennathur

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Sumita Pennathur leads a very full life?besides being an up-and-coming faculty member, she?s a mom, a professional jazz musician, and a marathon runner.

Sumita Pennathur, who joined the Department of Mechanical Engineering two years ago as an assistant professor, is developing nanofluidic devices for bioanalytical and energy applications. Her work involves understanding the unique physics of fluids at the nanoscale, and exploiting the phenomena she discovers by developing new biosensors, diagnostic devices, and energy conversion devices. When she isn?t working or enjoying time with her husband and young son, she moonlights as a professional jazz musician. She also co-authored a nanotechnology textbook when she had some downtime?during her maternity leave?and runs the occasional marathon. Convergence talked with Pennathur about her research, her perspective on work and life, and how she fits everything in.

Your primary field of research is nanofluidics?what exactly does that term mean?

Nanofluidics is the behavior of fluids at the nanoscale?the study of the transport of liquids and gasses confined in structures generally ranging from one to 100 nanometers in size. (A human hair is roughly 60,000 nanometers in diameter.) I?m really interested
in what happens at that scale, because the characteristics and behavior of fluids change quite dramatically at the nanoscale compared to microscale and up. One of my primary goals is to discover the specifics of those differences and their causes, and then to apply that knowledge toward creating useful micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) devices. While I do a lot of fundamental, or ?pure,? science in nanofluidics, I?m really an applied person at heart, and I have a passion for combining fundamental nanofluidics with MEMS and NEMS fabrication. I would hope that all my research could eventually result in devices or applications that can make a real difference in the world.

Were you always interested in engineering, or did you have other career aspirations early on?

When I was younger, I was always fascinated with how things worked and why they worked, but I clearly remember not wanting to be an engineer, because ?I didn?t want to get my hands dirty.? When I was admitted to MIT, I originally wanted to study biology and chemistry. I was so interested in how things worked, and in the major research contributions that were being made all around me, however, that I decided to major in aeronautics and astronautics. That major really appealed to my curiosity about how and why things work the way they do.

Most of us think of aeronautics and astronautics in terms of human scale and larger devices and systems. How did you get into the nanoworld?

When the microengine project, a big Army-funded project that was focused on making gas turbine engines the size of a dime, started at MIT, I immediately got involved with the research as an undergraduate. That?s where I learned a lot about MEMS technology. I was so interested, in fact, that I began my Ph.D. exploring cavitation in MEMS turbomachinery. It was then that I realized that I wanted to go even smaller. I applied to about 10 other graduate schools, and decided to finish my Ph.D. at Stanford in Mechanical Engineering. There I studied fundamental nanofluidic transport and also forayed into biology and chemistry, my earlier interests. I am now finally living my dream of combining MEMS and NEMS with fundamental science in nanofluidics, to create devices that can have major societal benefits in medicine and bioengineering.

How are you planning to do that?

One vision I have is to create a handheld diagnostic device that can be used where sophisticated medical infrastructure isn?t available?in the rural villages in India and Africa, for example?to rapidly and simply diagnose the medical problems of the people. I envision that even an illiterate person could use this device, with pictures for instructions, and wirelessly transmit the data to doctors in more developed areas. With the information from the device, the doctors could diagnose diseases and prescribe treatment for the people in remote communities not directly served by the medical
establishment.

Artist’s conception of a nanofluidic DNA separation device. DNA strands (or other biomolecules) are tagged with a fluorophore and injected into a nanofluidic channel using electric forces. Due to differences in electrophoretic mobility, charge, size, diffusivity and conformation, these molecules separate from each other. We can then identify groups of similar molecules by imaging the fluorescence and subsequently construct optical signatures based on the patterns and intensities of the separated groups.

I believe we can accomplish this with nanofluidics?using nanoscale channels to separate and identify DNA strands and form a sort of ?fingerprint? of what is in the sample.

We envision building a MEMS/NEMS device that has integrated electrodes and an integrated sample preparation system that allows you to analyze everything without bulky microscopes and other equipment. We are working with Andrew Cleland in physics, Frederic Gibou in mechanical engineering and computer science, Paul Atzberger in math, and Todd Squires in chemical engineering toward achieving this goal.

Are there other areas in which you?re looking to apply that knowledge?

Yes?a medical device is not the only vision I have. We?re looking at building nanofluidic chips for energy harvesting, and at building engineering devices for better fabrication of micro- and nanochannels. We also have a wide range of side projects, many led by undergraduates, focused on building engineered devices to make life easier in the lab?an automatic buffer preparation system, and an electrochemical discharge machining (ECDM)-based channel fabrication method are a couple of examples.

How do you think you fit into the engineering faculty here at UCSB?

Right now I think I stand out a bit because I?m a young, bright-eyed faculty member. I may be a bit naïve about the realities of being a professor, but I don?t care. I?m aiming really high. I truly believe I can help save the world through my research. Check back in a few years time?I aim to have a portfolio of accomplishments that rivals those of my amazing senior colleagues.

Of course, I?m also a (relatively!) young woman and mother, which stands out these days?it means my schedule is a bit different from my colleagues?. I have a husband
who works in corporate America, so I rely on the flexibility of my faculty schedule to take care of our three-year old son.

NanoLab Research Group: Left to right: (Top row) Veselin Kolev (ME undergraduate); Michael Love (ME undergraduate); David Herrick (masters student Materials Dept.) (Second row) Nolan Pasko (ME undergraduate); Alex Russell (ME undergraduate); Jess Sustarich (ME graduate student); Kristian Lund Jensen (visiting DTU undergraduate student, Denmark); (Third row) Jesper Toft Kristensen (visiting DTU undergraduate student, Denmark); Henrik Bruus (visiting DTU professor, Denmark); Sumita Pennathur (Fourth row) Mariateresa Napoli (ME postdoc); Tom Wynne (ME graduate student); Jared Frey (ME graduate student)

How has having a family affected your approach to your work?

The big challenge comes from the need to always make sure your child is well cared for, come what may? sickness, travel, day or night. My husband is great, but he?s a professional, too ? and there?s something about mothering that?s different from fathering, at least in our family. Bottom line is, I have to figure out a way to get my work done, tend to my household duties, and watch my child when he?s sick.

I?ve been working to make a difference along these lines. Together with Deborah Fygenson (associate professor of physics) and Maria Herrera-Sobek (professor of chicana and chicano studies), I helped initiate a pilot program offering backup dependent care. Through this program, a company called Work Options helps arrange for childcare when regular arrangements fail (a sick babysitter, a mildly sick child, a late dinner meeting, or just an irregular holiday) and an employee still needs to work, while the employer subsidizes the cost. The UCSB pilot is aimed at collecting data for two years to determine if the program is really cost effective. I don?t know how it will turn out, but I know it has helped me immensely!

Tell me about some of your exploits beyond engineering and your family?

Well, in addition to being a professor, I?m a jazz musician? I play the alto saxophone, and I feel like it really balances me. I had an all-female jazz trio, Ambika, in San Francisco when I was doing my Ph.D. at Stanford. We played a fusion of modern jazz improvisation with classical North and South Indian music. The band was a great outlet! I think I may actually have made more as a musician than a graduate student, at least hourly... Sadly, that band broke up due to the demands and locations of our respective
careers, but I still play here in Santa Barbara. In fact, our new band, fitz.MINOR, will be playing at SoHO (a music club and restaurant in downtown Santa Barbara) somewhat regularly?perhaps once every other month or so?and we have a Facebook fan page. In addition to playing music, I love cooking and running, which I try and get in between work and watching my son.

Given your impressive CV, which includes an undergraduate degree and graduate work at MIT, a Ph.D. from Stanford, and two prestigious postdoctoral positions, you must have had offers from other universities. Why did you choose UCSB?

I did have other offers, and I had a very hard time deciding, until my husband said to me, ?Go to where you will be the happiest.? Somehow, that really cinched it for me. It was an immediate decision. I knew I would be happiest at UCSB. The faculty here is amazing, the work/life balance is great, and the research facilities are some of the best in the world.

Have things turned out as you expected?

Definitely! I love what I do! I truly love my research and I love to teach. What?s funny is that many people think that the weather was a deciding factor for me, but it wasn?t. Had this group of faculty members been in Atlanta or Philadelphia, I would have been there in a second. I also think I have a better work/life balance here than I would elsewhere. I still work 100 hours a week, but there?s no demand to be in the office all the time. People judge me on the work I accomplish, not the time I spend on campus. I?m really proud to be one of the faculty here. My colleagues blow my mind in terms of what they know, and they?ve been extremely supportive.

What in particular do you love about teaching?

I love to talk and I love to perform. People either love or hate my teaching style, but when I get that one e-mail or note saying that I?m the best teacher they?ve had, well, that?s what I live for?Making a difference in people?s lives. I don?t think I would get as much appreciation at a place that doesn?t value teaching so much. When I was a student, I learned more from my student colleagues than from many of my professors. Here, the professors actually make a difference. That?s what I love.

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