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Biocomplexity Faculty Search Committee
c/o Prof. Rob de Ruyter van Steveninck
Biocomplexity Institute
Indiana University
Swain Hall West 117
Bloomington, IN 47405-7105

Dear Prof. Rob de Ruyter van Steveninck,

I am writing to you regarding a junior faculty position in a new interdisciplinary biocomplexity initiative at Biocomplexity Institute in Indiana University. Currently I am a postdoctoral appointee in the Biomolecular Materials & Interfaces department of Sandia National Laboratories, working with Dr. Bruce Bunker and Dr. Jack Houston. In this position, I have studied fundamental mechanisms for adsorption and desorption of proteins on switchable bio-active surface in aqueous solutions.

During my post-doc at the University of Houston with Prof. Scott Perry, I had performed scanning tunneling microscopy(STM) on the organic self-assembly of molecular nanowires. In this work, I succeeded in manipulating single molecules with STM tip to modify the orientation and configuration of nanostructures formed on the metal surfaces. Previously in Seoul National University, I constructed an entire AFM system (the first one to be used in Korea) including electronic circuits, software and mechanical design for my M. S. research project. For my Ph. D, I developed new techniques for magnetic force microscopy and nanolithography using electrostatic force modulation.

I am eager to have the opportunity to teach both graduate and undergraduate students in a lecture setting. In my experiences as a teaching assistant, I enjoyed lecturing and leading student discussion sessions. I also was the principle lecturer for two general physics classes for non-physics majors while teaching for a semester at Ajou University in Korea. It was rewarding to teach general physics to new students, and challenging to make them understand the material without using complicated physical terminology or calculus.

I have enclosed a curriculum vitae including a publication list, research plans and teaching philosophy for your consideration. I am confident that my combination of up-to-date nano-and bio-research experiences and solid educational experience has prepared me for making an immediate contribution to your department.

Thank you very much for your time and consideration and I will look forward to hearing from you.

Sincerely yours,

Byung-Il Kim

Research Plans

Byung-Il Kim

The recent availability of novel self-assembled materials, such as biomolecular materials, self-assembled monolayer and organic supramolecular assembly, allows the exploration of fundamental understanding in interfacial chemistry and biochemistry, and is now enabling the manipulation and study of nanofluidics and molecular devices. Recent advances have been made possible partly due to the invention of new experimental tools, such as scanning probe microscopy (SPM), and to the advance of device fabrication technologies.

Combining these new experimental techniques with nanoscale bio-organic self-assembled materials will produce ample opportunities to explore new bio-chemical phenomena, and may impact future technologies. *The focus of my proposed research is the investigation and manipulation of nanoscale self-assembled materials including biomolecular materials and their possible applications to nanoscale devices.*

Exploiting semiconductor device fabrication technologies and developing new synthesis and extraction methods of artificial and/or natural self-assembly material are essential for the proposed research. In this regard, interdisciplinary research efforts will be established in collaboration with biologists, chemists and material scientists. Described below are a few examples that I would like to study in my research group with such combining efforts.

In first part, I will describe my plans to manipulate bio-organic molecular materials using switchable bioactive surfaces by thermal and photo-activation. In second part, I will discuss research plans to investigate the fundamental aspects of biomolecular materials through the novel detection mechanism using modern state-of-art signal processing technique such as phase locked loop (PLL). In third part, I will describe possible application of self-assembled materials to nanoscale molecular devices.

1. Manipulation of Biomolecular Materials

We recently made a unique breakthrough in the fabrication of switchable bio-active surfaces by thermal activation(**Fig. 1**). This type of experiment will open pathways for the switchable and reversible control of interfacial interactions between proteins and biomolecular interfaces in complex biological fluids.

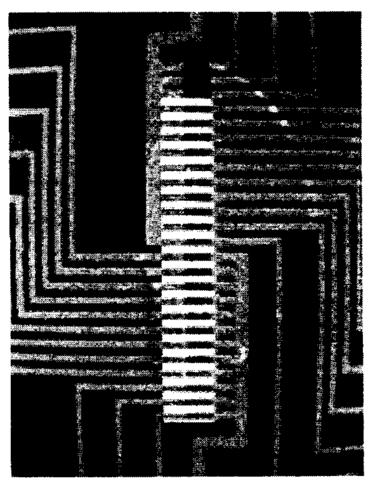

Fig. 1. Thin resistive gold heater elements for piano-key control in heating different portions of device using electrical current.

For biological applications, the use of light offers unique opportunities, as light fluxes are easy to control temporally and are less likely to perturb delicate biological structures than most other stimuli. In collaboration with

Professor Picraux's group of Arizona State University, we were the first to show that IFM can distinguish between aromatic ring-opening and closing after UV-VIS exposure on a surface in electrolyte liquid. I am interested in applying this system to transport bio-materials from one site to another as the light source moves.

I am also interested in unraveling the factors that control complex functions (i.e., protein transport, separation and detection) using photo- or thermal activation at the surface of biomaterials. The experimental measurements with SPM include the thickness of hydration layers on different surfaces and whether such layers result in attractive or repulsive interactions between surfaces and/or solution species such as proteins and other biomolecules.

2. Detection of Biological Materials using Nanomechanical Systems

I am interested in combining state-of-art communication skills and nanomechanical systems for rapid detection and analysis of biomolecular materials. For simple bio-sensing and actuation applications using nanomechanics, I would like to use a cantilever of the scanning probe system with phase coherent techniques to provide enhanced sensitivity.

Recently, I developed a simple and elegant phase locked oscillator(PLO) for advanced scanning probe applications(**Fig. 2**). I will use this system to improve the probing quality in complex biological fluids. Future projects will be aimed at applying these important and powerful techniques to bio-sensing arrays in conjunction with miniaturization.

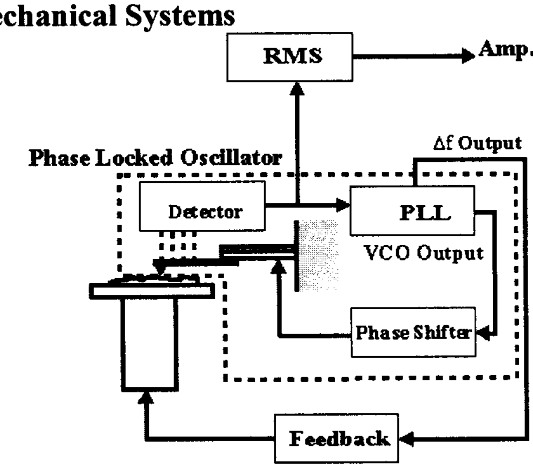

Fig. 2 Phase locked oscillator for the detection of biological materials and for the enhancement of effective viscosity under highly damped environment such as water.

I am also interested in imaging molecular scale biological structure under biological environment through control of effective viscosity using PLO. The active driving of cantilever vibration with PLO will reduce the viscosity of liquid artificially, improving image quality and data acquisition speed. In the same way, the spectroscopic method based on this technique will allow us to extract fundamental information of chemical and biological system on the molecular level.

3. Bio-Inspired Molecular Devices

Another objective of my research is to learn how to exploit molecular beams to create oriented assemblies of functional molecules on solid substrates. By controlling the flux, kinetic energy, and incidence angle of the molecular beam, it should be possible to create molecular assemblies that are substantially different than those produced using common solution synthesis techniques.

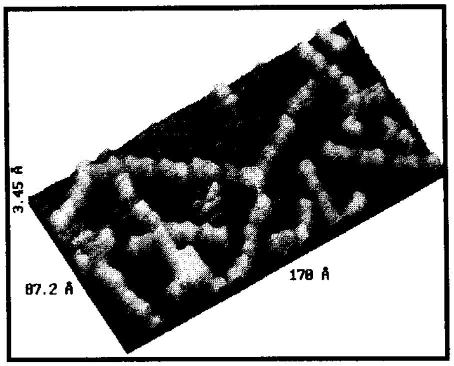

Fig. 3. Scanning Tunneling Microscope image of 4-trans-2-(pyrid-4-yl-vynyl) benzoic acid(PVBA), an organic molecule with two benzene rings and hydrogen bonding, on Pd(111) surfaces.

The starting point for this research is work that I performed a couple years ago involving the self-assembly of 4-trans-2-(pyrid-4-yl-vynyl) benzoic acid(PVBA) from organic molecular beam deposition. We could grow linear molecular wires of PVBA by using anchoring two benzene rings to hollow sites on fcc(111) and self-assembling PVBA molecules with hydrogen bonding(**Fig. 3**).

When the molecular beam is normal to the surface, these "molecular wires" are oriented along 6 distinctive orientations on Pd(111). However, other researchers have several years ago demonstrated that molecules can be oriented in specific directions corresponding to the direction of an angled incoming molecular beam.

As an interesting model system, I am interested in using scanning probe techniques to study the extended structures that can be produced by molecular beam deposition of the four different bases in a DNA molecule (adenine, cytosine, guanine and thymine). By varying deposition conditions and substrate interactions, it should be possible to produce molecular assemblies such as oriented molecular wires and lamellar structures whose structures and properties will be substantially different than the classical double helix produced in aqueous solutions.

Teaching Philosophy

Byung-Il Kim

Advising Students

I am interested in interacting with both graduate and undergraduate students. When I was a graduate student and research assistant at Seoul National University, I enjoyed working with and mentoring junior graduate students in our research group. It was particularly rewarding to me when interactions with students led to quick and innovative solutions to challenging technical problems. I found that I often learned as much from the students as they learned from me. Such interactions have been a valuable component of my career development. I look forward to mentoring a large group of students in my research group, and plan to work closely with the students both individually and in frequent group meetings. I believe that communication with students is the best way for me to pass on my valuable hands-on experiences to the next generation. Communication with students will also continuously expose me to new ideas on the frontiers of science.

Lecturing in Science

My research career has demonstrated to me that the best way to obtain a lasting and deep understanding of a given research topic is to teach lecture-style courses. I am eager to have the opportunity to teach both graduate and undergraduate students in a lecture setting. In my experiences as a teaching assistant, I enjoyed lecturing and leading student discussion sessions. I also was the principle lecturer for two general physics classes for non-physics majors while teaching for a semester at Ajou University in Korea. It was rewarding to teach mechanics to new students, and challenging to make them understand the material without using complicated physical terminology or calculus. My experiences as a lecturer taught me how to explain complicated concepts in a simple and concise fashion. I enjoyed stimulating my students' interest in course materials and helping them formulate their own ideas. My students must have also enjoyed the experience, as I have always received good reviews from my students.

Specific Teaching Goals and Experience

I am qualified to teach a wide range of subjects in fundamental physics including mechanics, electromagnetism, quantum physics, statistical and thermal physics, mathematical physics, and solid state physics. I would enjoy teaching these topics at both the graduate and undergraduate level. I would also like to develop specialized classes for both undergraduate and graduate students. For undergraduate students, I would like to teach a basic measurement course. My hope is that such a course would help creative students to identify the best experimental techniques for addressing specific scientific hypotheses. I am particularly interested in exposing students to modern techniques such as scanning probe microscopes that are useful in probing physical and chemical phenomena at the nano- and even molecular length scales. I would like to stimulate the scientific curiosity of my students in the world of nanotechnology by helping them understand how we can explore fundamental phenomena at the nanoscale. For graduate students, I would like to design an advanced course that will expose students to the research frontiers in nano- and bio-sciences. My development of many of the topics to be included in this course will rely directly on my own personal research experiences. Such topics include nanomagnetism, nanolithography, nanotribology, integrated nano-scale devices, and interfacial forces. Through this course, graduate students would be prepared to make their own unique contributions to the future of nano-science.