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Graphene Atomic-lattice Interferometry for Molecular Bio-Informatics: The Graphene Moleculography

Kyung-Suk Kim

Professor
School of Engineering,
Brown University,
Providence, RI

ABSTRACT:

Bio-informatic imaging of molecules and/or nano-particles at the atomic level, correlating it to their functionalities, has been elusive. Here, we report "graphene moleculography," a novel scientific method that provides the ability to investigate physical and/or chemical phenomena using only small number of molecules at the atomic scale. The moleculography is composed of (i) a "graphene molecular zipper" (GMZ) for alignment and manipulation of molecules on a graphene surface, (ii) AFM-based "graphene atomic lattice interferometry" (G-ALI) to resolve the molecular structure and its interaction state, and (iii) computational algorithms for the molecular informatics of G-ALI. Similar to the historical scientific-advancement example of X-ray/crystallography pair, the G-ALI/moleculography pair has potential to advance molecular science and technology with unprecedented resolution and versatility. In this talk, analysis of critical curvature localization in graphene caused by quantum flexoelectricity is included in the discussion to explain our discovery of graphene crinkles used in GMZ design. The GMZ utilizes invariant-mode bifurcation of multi-layer graphene crinkle, which creates flexoelectric charge concentration within sub-nanometer bandwidth along the crinkle ridges and valleys. Controlling the charge potential depth, the charge localization acts as a molecular zipper. The molecular zipper attracts and aligns bio-molecules, or nano-particles along the ridges or valleys. Once the molecules are zipped, nondestructive physical reading is made by the G-ALI applied on a passivation mono-layer graphene which covers the trapped molecules of interest. The G-ALI data are, then, used to identify the molecular structure and/or interaction states, analyzing the graphene atomistics with density functional theory (DFT).

BIOGRAPHY:

Kyung-Suk Kim has 37 years of experience as an engineering science faculty and is currently Professor of Engineering at Brown University, directing the Center for Advanced Materials Research. He received Ph.D. ('80) in Solid Mechanics from Brown University. After he spent one year ('79-'80) at Caltech as Research Fellow in aeronautics, he taught at TAM Department, University of Illinois, Urbana-Champaign for 9 years until he joined Brown as Professor of Engineering in 1989. He also held visiting faculty positions at Harvard University ('87-'88 and 2002), Cambridge University, U.K. ('96), University of California, Santa Barbara ('97), Distinguished Visiting Scientist at KIST ('08) and Simpson Visiting Faculty Fellow ('13) at Northwestern University. His interests are in interdisciplinary research on advanced small-scale material structures in both experiment and theory. Through his research, he has invented numerous new scientific instruments and analytical methods, including various high-resolution interferometers and field-projection methods. As an educator, he has advised more than 37 PhD students and Postdocs. He is a recipient of the Melville Medal from ASME (1981), the John Simon Guggenheim Fellowship (1996), the Ho-Am Prize in Engineering (2005), the Kwan-Ak Distinguished Alumni Award of Seoul National University (2012), the Engineering Science Medal from the Society of Engineering Science (2012), and the Daniel C. Drucker Medal from the American Society of Mechanical Engineers (2016).