For the entire history of mankind, the treatment of disease has been limited by the simple fact that diagnosis follows the appearance of symptoms. While we do administer prophylactics in cases of known exposure and high risk, and recommend regular check-ups to identify onset of illness based on genomic analysis and epidemiologically determined environmental risk factors, the question still remains - how would medicine change if pre-symptomatic diagnosis were commonplace? From the simplest perspective, drugs work better when applied earlier in infection and could in cases be replaced by immune system adjuvants. More interesting would be the capability of pre-symptomatic determination of an dropping odds unknown infection state, for example during the 2003 SARS coronavirus or 2009 Influenza outbreaks, or after a biothreat.

To address the challenge, we have developed a platform capable of detecting single nanoparticles and viruses with high throughput, no amplification and at low cost. Interferometric, multi-color imaging on simple substrates provides the ability to rapidly scan and identify size, shape, orientation and material properties of single nanoparticles and viruses. To detect and size pathogens, our Interferometric Reflectance Imaging Sensor (IRIS) shines light from multi-color LED sources sequentially on viruses and nanoparticles bound to the sensor surface, which consists of a silicon dioxide layer atop of a silicon substrate. Interference of light reflected from the sensor surface is modified by the presence of particles producing a distinct signal that reveals the size of the particle. In our approach the dielectric layered structure acts as an optical antenna optimizing the elastic scattering characteristics of nanoparticles for sensitive detection and analysis.

We have successfully detected 35 nm and 50 nm radius particles and H1N1 viruses (illustrated in the conceptual picture, right) with accurate size discrimination. Au nanoparticle tagging allows us to detect attogram (sub-picomolar) quantities of biomarkers on a platform capable of high-throughput screening. Our current limit of detection is < 100aM for protein in serum and < 500aM in whole blood. From the perspective of disease diagnosis and treatment, we have recently achieved sensitivity of less than 104 pfu/ml of an Ebola virus analog in serum, and explored multiplexed detection of Ebola, Marburg and Lasa pseudotypes at pre-symptomatic concentration in blood.

ABOUT THE SPEAKER

Bennett B Goldberg is a Professor of Physics, with joint appointments in Biomedical and Electrical and Computer Engineering. He is the founder and director of the Center for Nanoscience and Nanobiotechnology and former chair of the Department of Physics. At the Center, he directs the Boston University Nanomedicine Program. He is also the Director of STEM Education Initiatives for Boston University. Goldberg received a B.A from Harvard College in 1982, an M.S. and Ph.D. in Physics from Brown University in 1984 and 1987. Following a Bantrell Post-doc at MIT and the Francis Bitter National Magnet Lab, he joined the physics faculty at Boston University in 1989. Goldberg is a Fellow of the American Physical Society, has been awarded a Sloan Foundation Fellowship and is a recipient of the Presidential Young Investigators Award. Current research and training interests include Nanomedicine, biosensing and nano-optics of graphene and other 2D materials.