Playing pool with atoms

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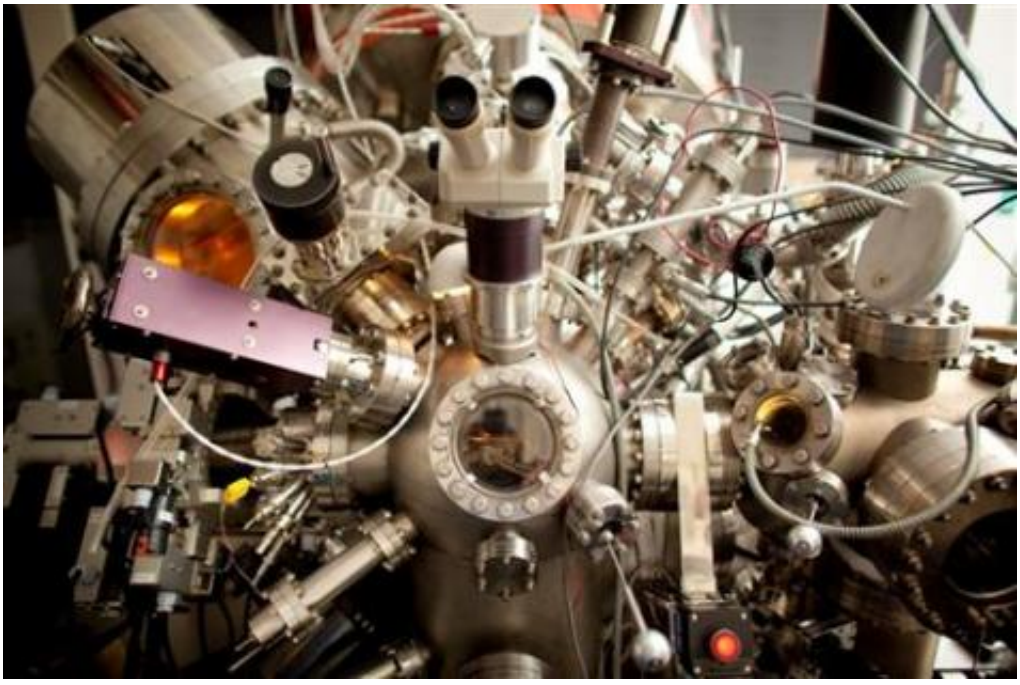

Lehigh's powerful high-resolution X-ray photoelectron spectrometers (HR-XPS), the only of its kind in the U.S., can determine the chemical nature of atoms in a material's surface region and is a perfect complement to the new HS-LEIS. Photo by Douglas Benedict

(PhysOrg.com) -- The scientist who developed the world's most sensitive spectrometer for identifying atoms on a material's surface came to Lehigh recently to give a talk at the only U.S. lab that is equipped with his cutting-edge instrument.

Hidde Brongersma, a professor at Imperial College in London, England,

delivered the keynote address at the Lehigh University Surface Analysis Symposium.

The event, held in Whitaker Laboratory, drew 150 scientists from industry and academia.

Brongersma, who was formerly associated with Eindhoven University of Technology in The Netherlands, is inventor of the ION-TOF Qtac100 High Sensitivity-Low Energy Ion Scattering Spectrometer (HS-LEIS). Low-energy ion scattering is the only technique that can identify the atoms present on the outermost layer of a solid surface (~0.3 nanometer depth resolution; 1 nm equals a billionth of a meter).

“Whether you are trying to develop a new catalyst, fabricate a smaller transistor, or improve the adhesive properties of a polymer surface,” said Brongersma, “it is extremely important to be able to control surface properties at the atomic level.

“In order to do this, you must be able to analyze the surface composition with the same precision.”

A powerful pair

To analyze the surface of a sample, one must not only identify the atoms present but also determine their chemical nature, such as the oxidation state.

Lehigh is also fortunate to have one of the most powerful high-resolution X-ray photoelectron spectrometers (HR-XPS) capable of determining the chemical nature of the atoms in the surface region. The university’s Scienta ESCA 300, one of 11 in the world, is the only one of its kind in the U.S.

“While XPS is not as surface sensitive as HS-LEIS, it can provide very useful chemical information from the top 10-20 atomic layers of a material,” said Israel E. Wachs, the G. Whitney Snyder Professor of chemical engineering.

“Being able to combine data from both these techniques enables Lehigh and visiting researchers to gain a new perspective on the surfaces of many of today’s technologically important materials.

“The unprecedented and fundamental insights being provided by these surface techniques are already beginning to change our understanding of the surfaces of technologically important materials while establishing basic structure-performance relationships that assist in designing advanced materials.”

A cue ball of noble gas ions

The physical principles behind the HS-LEIS technique are similar to that of a game of pool, but instead of a cue ball, noble gas ions, such as helium or neon, are fired at the surface of a sample.

The gas ion interacts with a surface atom similar to the way in which a cue ball hits another pool ball. It may either bounce straight back from the sample or be deflected at an angle, and a fraction of its momentum (or energy) is transferred to the surface atom.

The amount of energy lost is directly related to the atomic weight of the surface atom. The energy of the rebounding noble gas ions is measured in the spectrometer, which can then be related back to unequivocally determine the identity of the atom from which it was scattered.

The unique design of the instrument’s toroidal Qtac100 energy analyzer, which includes a position-sensitive detector and time-of-flight mass

filter, offers a 3,000-fold improvement in sensitivity over its predecessors and also allows for two-dimensional surface mapping.

Other presentations in the workshop were given by Wachs, who directs Lehigh's Operando Molecular Spectroscopy and Catalysis Research Laboratory; Alfred Miller, a research scientist who manages the Scienta XPS laboratory; and Andriy Kovalskiy, a research associate affiliated with Lehigh's International Materials Institute for New Functionality in Glass, which is supported by the National Science Foundation.

Provided by Lehigh University