



# Physics colloquium

**Visualizing and Shaping the Nanoworld: From the Quantitative Interrogation of Site- and Species-Specific Interactions of Atoms to the Millimeter-Scale Engineering of Structures with Angstrom Precision**

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Date: **3/22/19**

Time: **10:30AM**

Location: **COB2 170**

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**Abstract:** The interactions a material exhibits with the environment are largely determined by the properties of the material's surfaces. In the first part of this talk, we describe recent efforts to characterize a surface's structure by enabling species-specific atomic resolution imaging and quantify chemical interaction strengths in three dimensions with picometer and piconewton resolution using noncontact atomic force microscopy [1-3] and outline how this information can be combined with local electronic information [4, 5]. Applications to explore topics such as surface chemistry or the atomic origins of friction will be presented for various model systems including oxides, metals, ionic crystals, and layered materials, with the ultimate goal to obtain a complete toolbox for the single-molecule characterization of surface reactions.

In the second part of the talk, we will then expand on the theme of atomic-scale manipulation by asking how surface morphologies of samples as large as multiple mm<sup>2</sup> can be shaped at will with Angstrom precision. Here we demonstrate the imprinting of atomic step edges of a SrTiO<sub>3</sub> single crystal used as mold into a Pt-based bulk metallic glass (BMG) [6]. Systematic studies revealed that (i) terraces on the BMG replicas possess atomic smoothness, (ii) the same mold can be used multiple times without degradation of mold or replicas, and (iii) the atomic-scale features on as-imprinted BMG surfaces have impressive long-term stability (years), thereby opening the possibility to induce surface properties by imprinting appropriate atomically defined surface morphologies.

**Bio:** Udo D. Schwarz graduated in 1989 from the University of Basel, Switzerland, receiving his Ph.D. in physics from the same institution in 1993. Subsequently, he continued his work as a staff scientist and lecturer at the Institute of Applied Physics of the University of Hamburg, Germany. In 2001, Prof. Schwarz moved to the Materials Science Department of the Lawrence Berkeley National Laboratory in Berkeley, California. Since 2002, he works at Yale's Mechanical Engineering Department, where he got promoted to full professor in 2009 and serves as department chair since 2012. His research interests concern the local measurement of atomic-scale interactions and properties, including mechanical, electrical, and chemical interactions, to study materials science problems in surface physics and chemistry such as issues related to heterogeneous catalysis, nanotribology (atomic mechanisms of friction), elastic deformation, and plastic flow. Towards this end, the group specializes in the further development of scanning probe microscopy methods.

