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Control of Atomic Vapors and Nanoparticles

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Controlling the transport of matter at atomic and nano length scales holds promise for enabling lower-power and smaller atomic instruments as well as the fabrication of novel optical components. In this presentation, I discuss two projects, (1) solid-state electrochemical control of atomic vapors for compact cold-atom sensors and clocks and (2) scalable self-assembly of nanoparticles into 3D hierarchal microspheres.

Atomic instruments using laser-cooled atoms in ultra-high vacuum enable highly precise measurements of time, acceleration, and rotation. Use of such devices outside the laboratory requires control of the atomic vapor density to prevent warm atoms from prematurely disturbing the cold atoms prior to measurement. Portable, miniature cold atom devices require a low-power, scalable method for controlling atomic vapor density. This talk presents an electrochemical device based on alkali ion-conducting beta"-alumina solid electrolyte. Further, it shows the dynamic manipulation of alkali vapor pressure under ultra-high vacuum and demonstrates application to cold atoms.

High index contrast coatings can enable frequency-selective reflectors or absorbers in the visible and infrared; however, vapor deposition methods limit the size, shape, and quantity of objects that can be coated. Sprayed or solution-deposited coatings with ordered arrangements of high index contrast visible and infrared transparent materials would overcome these limits. This presentation describes rapid and scalable processes that use pH-control of electrostatic surfaces charges and control of liquid-liquid interfaces to assemble heterogeneous micro-structures from diverse classes of nanoparticles for omnidirectional IR reflection and scattering.

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Dr. Christopher Roper is a Senior Scientist in the Materials and Microsystems Laboratory at HRL Laboratories, LLC. He earned a B.S.E. in Chemical Engineering from Case Western Reserve University in 2002 and a Ph.D. in Chemical Engineering from the University of California at Berkeley in 2007, where he was a member of the Berkeley Sensor and Actuator Center (BSAC). He joined HRL Laboratories, LLC in 2008 where he has led multiple internal and contract research and development projects in the areas of heat and mass transfer for materials and systems across a wide range of length scales. He has authored 37 peer-reviewed articles and is inventor on over 36 granted patents. His research interests include atomic physics, MEMS, micro & nanofabrication, heat & mass transfer, and architected materials.

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