OPTICAL SCIENCE & ENGINEERING
University of New Mexico

OSE SEMINAR SERIES

Dr. Robert Opila

Dept. of Material Science and Engineering, University of Delaware

Thursday, September 26, 2019 at CHTM, Room 101 from 12:15 PM to 1:15 PM

In Operando XPS Study on Atomic Layer Etching of Fe and Co Using Cl_2 and Acetylacetone or Hexafluoroacetylacetone

Abstract:

Etching of transition metals is one of the major challenges in magnetoresistive random-access memory (MRAM) device fabrication. In this work, atomic layer etching of iron and cobalt surfaces in sequential steps of exposure to halogen and an organic molecule was studied. We successfully performed etching of Fe and Co thin films through the formation of volatile metal complexes at low temperature with cyclic reactions of Cl_2 and acetylacetone (acacH) or hexafluoroacetylacetone (hfacH). The etching reaction mechanism of acac and hfac reacting with chlorine-modified Fe and Co surfaces was investigated: the surface was first activated with Cl_2 gas, and subsequently, the top layer of chlorinated metal was removed by reaction with a diketone (acacH/hfacH) as shown in the photoemission spectra. The extent of Cl_2 reaction determines the etching rate of the metal. At substrate temperatures lower than 135°C, acac could remove the chlorinated Fe metal layer from Fe surfaces, but not chlorinated Co from Co surfaces. *In-operando* x-ray photoelectron spectroscopy (XPS) and density functional theory (DFT) simulation shows that the reaction of acacH or hfacH with chlorinated Fe or Co surfaces is likely following a complex reaction pathway instead of a simple diketone substitution for the metal chloride. Diketone decomposition likely plays an important role in the etching process.

Time will be set aside at the end of the talk for an open discussion about the National Science Foundation, in particular, the Division of Materials Research, and the Electronic and Photonic Materials Program.

Biography:

Robert L. Opila received a Ph.D. in Chemistry from the University of Chicago. He then joined Bell Laboratories, where he studied the role of surfaces and interfaces in electronic and photonic materials and devices. He was named Distinguished Member of Technical Staff and promoted to Technical Supervisor. Since 2002, he has been with the Materials Science Department at the University of Delaware, where his research now includes photovoltaic and thermoelectric materials as well as semiconductor processing. Opila also has appointments in the Departments of Electrical Engineering and Chemistry.

Dr. Opila is a Fellow of the American Vacuum Society and an editor of Applied Surface Science. He has completed terms as Fulbright Fellow at Bilkent University in Ankara, Turkey, and as Visiting Professorial Fellow at the University of New South Wales in Sydney, Australia. In 2015-16 he served as president of the faculty senate at the University of Delaware. Opila is currently an IPA program director of the Electronic and Photonic Materials Program, in the Division of Materials Science at the National Science Foundation.

Contact: Doris Williams 272-7764, dorisw@chtm.unm.edu

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