Dr. Lawrence F. Allard
Distinguished Research Staff Member
Oak Ridge National Laboratory, Oak Ridge, TN 37830-6064

EDUCATION AND TRAINING

PhD(Materials Engineering) University of Michigan (1981)
MSE(Metallurgical Engineering) University of Michigan (1969)
BSE(Science Engineering) University of Michigan (1967)

Employed in electron microscopy and materials studies continuously since 1963. Early worker in *in situ* microscopy studying Cu oxidation (1965-1967) at U of Michigan. Resumed *in situ* studies in 2006 in collaboration with Protochips Co., developers of a unique new EM heating technology based on microfabricated heater devices (trade name "Aduro™"). PI on acquisition of first commercial aberration-corrected STEM/TEM instrument in US (JEOL 2200FS, 2004), and have demonstrated single-atom resolution at high temperatures with this instrument. Recently developed *in situ* gas cell capability.

RESEARCH AND PROFESSIONAL EXPERIENCE

1997-pres: **Distinguished Research Staff Member**, Oak Ridge National Laboratory, Oak Ridge, TN. Primary research activities: Application of aberration-corrected STEM/TEM for: *in situ* characterization of catalysts and other nanophase materials; studies of precipitation processes in Al alloys; studies of structures in Fe-N magnetic materials.

1986-1997: **Senior Research Staff Member**, Oak Ridge National Laboratory, Oak Ridge, TN. Primary research activities: High resolution electron microscopy, electron holography and other instrumental analysis techniques applied to studies of ceramic materials, catalysts, composites.

1984-1986: **Principal Research Scientist**, American Cyanamid Co., Stamford Research Laboratories, Stamford, CT. Primary research activities: High-resolution and analytical electron microscopy of catalysts, ceramics and metal-coated carbon fiber composites.

1981-1984: **Assistant Research Scientist**, Department of Materials and Metallurgical Engineering, University of Michigan, Ann Arbor, MI.
Associate Director, Electron Microbeam Analysis Laboratory, U of Michigan

1971-1981: **Research Associate I and II**, Department of Materials and Metallurgical Engineering, University of Michigan, Ann Arbor, MI. Senior staff member of EMAL

1969-1971: **Development Engineer**, Materials and Structures Department, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, TN. Electron microscopy of diffusion barrier materials

AWARDS AND HONORS

- Elected Fellow, Microscopy Society of America (second Fellows class, 2010)
- Best Paper Award, Physical Sciences; *Microscopy & Microanalysis*, V.16 (2010)
- Lead Scientist, Lockheed-Martin Director's Award, Outstanding Team Accomplishment in Science and Technology, 2005
- Elected Director, Physical Sciences, Microscopy Society of America (2010-12)

SELECTED PUBLICATIONS

- Melanie Moses-DeBusk, Mina Yoon, **Lawrence F. Allard**, David R. Mullins, Zili Wu, Xiaofan Yang, Gabriel Veith, G. Malcolm Stocks, and Chaitanya K. Narula; "CO Oxidation on Supported Single Pt Atoms: Experimental and Ab Initio Density Functional Studies of CO Interaction with Pt Atom on **θ**-Al_2O_3(010) Surface;" ***J. Am. Chem. Soc.*****,** 2013, **135** (34), pp 12634–12645
- Ming Yang, **Lawrence F. Allard** and Maria Flytzani-Stephanopoulos, "Atomically Dispersed Au–$(OH)_x$ Species Bound on Titania Catalyze the Low-Temperature Water-Gas Shift Reaction;" ***J. Am. Chem. Soc***., 2013, 135 (10), pp 3768–3771,
- "CO Oxidation on Supported Single Pt Atoms: Experimental and Ab Initio Density Functional Studies of CO Interaction with Pt Atom on **θ**-Al_2O_3(010) Surface;" Melanie Moses-DeBusk, Mina Yoon, **Lawrence F. Allard**, David R. Mullins, Zili Wu, Xiaofan Yang, Gabriel Veith, G. Malcolm Stocks, and Chaitanya K. Narula; ***J. Am. Chem. Soc.*****,** 2013, **135** (34), pp 12634–12645
- "Surface Composition Tuning of Au–Pt Bimetallic Nanoparticles for Enhanced Carbon Monoxide and Methanol Electro-oxidation;" J. Suntivich, Z. Wu, C.E. Carlton, J. Kim, B. Han, S.W. Lee, N. Bonnet, N. Marzani, **L.F. Allard**, H.A. Gasteiger, K. Hamad-Schifferli and Y. Shao-horn, ***J. Am. Chem. Soc.*****,** 2013, **135** (21), pp 7985–7991 PTS 45547
- "Atomic Structure and Composition of "Pt_3Co" Nanocatalysts in Fuel Cells: An Aberration-Corrected STEM HAADF Study;" B. Patrick, H.C. Ham, Y. Shao-Horn, **L.F. Allard**, G.S. Hwang and P.J. Ferreira; ***Chem Mater***, 2013, **25** (4), pp 530–535, **DOI:** 10.1021/cm3029164 PTS 45549
- **Lawrence F. Allard**, Maria Flytzani-Stephanopoulos and Steven H. Overbury, "Behavior of Au Species in Au/Fe_2O_3 Catalysts Characterized by Novel *In Situ* Heating Techniques and Aberration-Corrected STEM Imaging," ***Microsc. Microanal.*** **16**, 375–385 (August 2010). **(Best Paper Award, 2010)**
- Botao Qiao, Aiqin Wang, Xiaofeng Yang, **Lawrence F. Allard**, Zheng Jiang, Yitao Cui, J. Liu, J. Li and T. Zhang "Single-atom catalysis of Pt1/FeOx for CO oxidation," *Nature Chemistry* 16, 634-641 (Aug 2011) **(First direct imaging of a single-atom catalyst)**
- **Lawrence F. Allard**, Wilbur C. Bigelow, Miguel Jose-Yacaman, David P. Nackashi , John Damiano and Stephen E. Mick, "A new MEMS-based system for ultra-high-resolution imaging at elevated temperatures," ***Microscopy Res & Tech*****, 72**(3), 208 – 215 (2009)
- Byungkwon Lim, Hirokazu Kobayashi, Pedro H. C. Camargo, **Lawrence F. Allard**, Jingyue Liu and Younan Xia, "New Insights into the Growth Mechanism and Surface Structure of Palladium Nanocrystals," ***Nano Res*** **3**: pp 180-88 (2010)
- M A Asoro, D Kovar, Y Shao-Horn, **L F Allard** and P J Ferreira, "Coalescence and sintering of Pt nanoparticles: *in situ* observation by aberration-corrected HAADF STEM," ***Nanotechnology*** **21**(2) 025701 (2010).
- Ja Hun Kwak, Jianzhi Hu, Donghai Mei, Cheol-Woo Yi, Do Heui Kim, Charles H.F. Peden, **Lawrence F. Allard** and Janos Szanyi, "Co-ordinatively Unsaturated Al^{3+} Centers as Binding Sites for Active Catalyst Phases of Platinum on g-Al_2O_3," ***Science*****, 325**, Issue 5948, pp.1670-73 (September 2009)
- **Lawrence F. Allard**, Albina Borisevich, Weiling Deng, Rui Si, Maria Flytzani-Stephanopoulos and Steven H. Overbury, "Evolution of gold structure during thermal treatment of Au/FeO_x catalysts revealed by aberration-corrected electron microscopy," ***J Electron Microscopy*** **58**(3):199-212 (2009)
- Jingyue Liu and **Lawrence F. Allard**, "Surface Channeling in Aberration-Corrected Scanning Transmission Electron Microscopy of Nanostructures," ***Micros and Microanal*****, 16**(4), 425-433 (August 2010)