



COLUMBIA | ENGINEERING

The Fu Foundation School of Engineering and Applied Science

The Department of Chemical Engineering
Columbia University

2017 Gaden Memorial Lecture

presented by

Mark Verbrugge

Director, Chemical and Materials Systems Lab

General Motors Research and Development, Warren, MI, USA



MARK VERBRUGGE started his career in 1986 with the GM Research Labs after receiving his doctorate in chemical engineering from the University of California, Berkeley. In 1996, Mark was awarded a Sloan Fellowship to the Massachusetts Institute of Technology, where he received an MBA. Mark returned to GM in 1997 as chief engineer for energy management systems in GM's Advanced Technology Vehicles. In 2002, Mark rejoined the GM Research Labs as director of the Materials and Processes Lab, which maintains global research programs ranging from chemistry, physics, and materials science to the development of structural subsystems and energy storage devices. The Lab was later expanded in scope and is now the Chemical and Materials Systems Laboratory. Mark has published and patented in areas associated with electroanalytical methods, polymer electrolytes, advanced batteries and supercapacitors, fuel cells, high-temperature air-to-fuel-ratio sensors, surface coatings, compound semiconductors, and manufacturing processes related to automotive applications of structural materials.



Mark is a board member of the United States Automotive Materials Partnership LLC and the United States Advanced Battery Consortium LLC, and an adjunct professor for the Department of Physics, University of Windsor, Ontario, Canada.

Mark's research efforts resulted in his receiving the Norman Hackerman Young Author Award and the Energy Technology Award from the Electrochemical Society as well as GM internal awards, including the John M. Campbell Award for research accomplishments, the Charles L. McCuen Award (twice) for inventions substantially influencing GM products, and the Boss Kettering Award (twice), the highest technical award given by GM. Mark received the Lifetime Achievement Award from the United States Council for Automotive Research, is a fellow of the Electrochemical Society, and is a member of the National Academy of Engineering.

Abstract: For personal transportation, vehicle electrification continues to grow in importance. We review recent electrified vehicle architectures and battery technologies. For battery electric vehicles (EVs) to gain significant market share, significant improvements in battery technology are needed, particularly in terms of decreased cost and increased energy density. These needs, associated cell requirements, and advances in our understanding of the active materials that are central to the performance of today's batteries, and likely those of the next decade, are overviewed.

In the second portion of this talk, I will focus on two technological pathways emerging for EVs: fast-charge-capable batteries versus batteries with much higher energy densities (and specific energies) but without the capability to fast charge. How do we compare and contrast the two alternatives? We seek to shed light on this question with a simple model that considers costs to the EV customer.

*The Department of Chemical Engineering
at Columbia University
is pleased to announce*

THE ELEVENTH ANNUAL GADEN MEMORIAL LECTURE:

Research Highlights Associated with Advanced Traction Batteries and Electrified Vehicles

presented by

Mark Verbrugge

Director, Chemical and Materials Systems Lab

General Motors Research and Development, Warren, MI, USA

Tuesday, October 10, 2017

4:00 p.m.

Davis Auditorium

412 Center for Engineering and Physical Science Research (CEPSR)

Columbia University

ELMER L. GADEN JR., widely known as the “father of biochemical engineering,” received all of his degrees from Columbia. Shortly after receiving his doctorate in 1949, he became a faculty member and remained at Columbia, often serving as department chair, until 1979. He was the founding editor of *Biotechnology and Bioengineering* (1959 –1974) and retired as



Willis Johnson Professor from the University of Virginia in 1994. He received many awards throughout his career for scholarship, outstanding teaching, and service to the many professional organizations he served. In 2009 he was awarded the NAE Fritz and Delores Russ Prize, one of engineering’s highest honors, in recognition of the profound effect of his work and leadership on the large-scale production of antibiotics following the Second World War. Professor Gaden died on March 10, 2012.

PAST GADEN LECTURERS

George Georgiou	2007	Manfred Morari	2012
Frank Bates	2008	Enrique Iglesia	2013
Frances Arnold	2009	Nicholas A. Peppas	2014
John H. Seinfeld	2010	Joan F. Brennecke	2015
Chaitan Khosla	2011	Paula Hammond	2016