Exponent®
Engineering & Scientific Consulting


# George Dimitrakopoulos, Ph.D., P.E., CFEI, CVFI

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## Professional Profile

Dr. Dimitrakopoulos has a degree in mechanical engineering and works in Exponent's Thermal Science Practice. His core areas of expertise include fluid mechanics, heat-transfer, mass-transfer, combustion, thermodynamics, reaction kinetics, computational fluid dynamics (CFD), energy storage, electrochemistry, catalysis, electrocatalysis, material synthesis and characterization. He consults on the following areas:

1. Fire and explosion investigations (determination of origin and cause, vehicle fires)
2. Consumer products (performance and safety evaluation of prototype and in-production devices, DFMEAs, CPSC matters, etc.)
3. Combustible dust matters (inspection of facilities handling/producing combustible dust, combustible dust testing based on applicable standards, Dust Hazard Analysis (DHA) etc.)
4. Green hydrogen and ammonia (fuel cells and electrolyzers)
5. Energy storage (li-ion battery failure investigation, cell-, pack-, and device-level thermal runaway testing and evaluation, etc.)
6. HVAC system review and analysis
7. Burn injury matters
8. Intellectual property cases
9. Catalysis and catalytic reactors
10. Exhaust aftertreatment and emissions systems
11. Oil and gas (reactor design and characterization, system safety, process evaluation, catalyst characterization etc.)

Prior to joining Exponent, Dr. Dimitrakopoulos was a Ph.D. candidate in the Reacting Gas Dynamics Laboratory at the Massachusetts Institute of Technology (MIT), Department of Mechanical Engineering. He obtained his Ph.D. in Mechanical Engineering in 2017, with a thesis in Mechanical Engineering and Computation. During his Ph.D., he investigated the production of added-value chemicals using ceramic membrane reactors. Through a novel experimental setup, transport and kinetic parameters were obtained and used to provide insight into the material properties and to develop 3D reactive flow CFD algorithms that would assist the design of optimized reactor modules for the conversion processes of interest. In 2014, Dr. Dimitrakopoulos completed a 3-month internship program at ExxonMobil's Upstream Research Company in Houston, TX, working on the development of computational models for process stratigraphy applications.

After his graduation, Dr. Dimitrakopoulos remained at MIT as a post-doctor and was later promoted to a Research Scientist. During this period, he worked on improving the performance of solid oxide fuel/electrolysis cells for green hydrogen and ammonia production by careful tuning of material properties. His research was both applied and fundamental with the aim to translate advances in the science of ceramic materials into real solid oxide cell devices. To this end, he investigated the concept of catalyst

exsolution to produce nanoparticle-sized, well dispersed, and long-term stable catalysts on the surface of perovskite oxide electrodes grown in-situ from the bulk of the material. He also experimented with proton-conducting electrolysis cells toward the production of green/blue ammonia from steam/methane and renewable electricity.

In 2021, Dr. Dimitrakopoulos was awarded the prestigious Kavanaugh Fellowship offered by the Department of Materials Science & Engineering at MIT. As a Kavanaugh Fellow, he investigated the oxidative coupling of methane to produce ethylene using thermochemical and electrochemical routes. He also conducted techno-economic analyses to evaluate the conditions under which these technologies could compete with the current industrial ethylene production routes (steam cracking of ethane or naphtha).

Dr. Dimitrakopoulos has extensive experience in synthesizing materials from raw precursors as well as characterizing materials using ex-situ (XRD, SEM, TEM, EDS, BET, XPS, XAS, TGA, DSC etc.) and in-situ (NAP-XPS etc.) techniques. He is an expert in the sintering of ceramic materials, the fabrication and testing of lab-scale solid oxide cells and the manufacturing of large-scale ceramic oxide devices. He is proficient in electrochemical characterization methods (I-V, electrochemical impedance spectroscopy, battery cycling etc.) and the analysis/quantification of gaseous mixtures.

## Academic Credentials & Professional Honors

Ph.D., Mechanical Engineering, Massachusetts Institute of Technology (MIT), 2017

B.S., Mechanical Engineering, National Technical University of Athens, 2012

Kavanaugh Translational Innovation Fellowship, Department of Materials Science & Engineering, Massachusetts Institute of Technology, 2021

George and Marie Vergottis Presidential Fellowship, Massachusetts Institute of Technology, 2012-2013

Onassis Foundation Scholar, 2012-2016

National Hellenic Research Foundation Scholar, 2007-2012

## Licenses and Certifications

Professional Engineer Mechanical, California, #41768

Professional Engineer Mechanical, Maine, #PE19138

Professional Engineer Mechanical, Nevada, #033507

Professional Engineer, North Carolina, #059586

Blasting Certificate of Competency (MA)

Certified Fire and Explosion Investigator (CFEI)

Certified Vehicle Fire Investigator (CVFI)

## Prior Experience

Research Scientist, Massachusetts Institute of Technology, Departments of Mechanical Engineering and Nuclear Science & Engineering, Cambridge, MA, USA, December 2019 – March 2022

Postdoctoral Associate, Massachusetts Institute of Technology, Departments of Mechanical Engineering and Nuclear Science & Engineering, Cambridge, MA, USA, January 2017 – December 2019

Research Assistant, Massachusetts Institute of Technology, Department of Mechanical Engineering, Cambridge, MA, USA, September 2012 – January 2017

Intern, ExxonMobil, Upstream Research Company, Houston, TX, USA, May 2014 – August 2014

## Professional Affiliations

National Association of Fire Investigators (NAFI)

National Fire Protection Association (NFPA)

International Organization for Standardization (ISO)

- Member of the ISO Technical Committee 197, Working Group 34 that develops the ISO 22734 Standard, “Hydrogen generators using water electrolysis - Part 1: General requirements, test protocols and safety requirements”.

## Languages

French (France)

Greek

English

## Patents

Ahmed F. Ghoniem, B. Yildiz, G. Dimitrakopoulos. Methane Upgrade to Ethane and Ethylene Within Ceramic Membrane Reactors. US Patent Application 17/243,219, 2022.

## Publications

H. Kytömaa, A. Wechsung, G. Dimitrakopoulos, N. Cook, D. Jaimes, I. Hur, S. Faraji. Industry R&D needs in hydrogen safety. Applications in Energy and Combustion Science 18 (2024) 100271.

A. Wechsung, M. Barry, G. Dimitrakopoulos, R. Spray, F. Colella, T.J. Myers, Lithium-Ion Battery Fire Investigation Fundamentals, International Symposium on Fire Investigation Science & Technology, Orlando, FL 2024.

S. Koohfar, M. Ghasemi, T. Hafen, G. Dimitrakopoulos, D. Kim, J. Pike, S. Elangovan, E.D.Gomez, B. Yildiz. Improvement of oxygen reduction activity and stability on a perovskite oxide surface by electrochemical potential. Nature Communications (2023) 14:7203.

F. Orsini, D. Ferrero, S.F. Cannone, M. Santarelli, A. Felli, M. Boaro, C. Leitenburg, A. Trovarelli, J. Llorca, G. Dimitrakopoulos, A.F. Ghoniem. Exsolution-enhanced reverse water-gas shift chemical looping activity of Sr2FeMo0.6Ni0.4O6-δ double perovskite. Chemical Engineering Journal 475 (2023) 146083.

H.G. Seo, A. Staerz, G. Dimitrakopoulos, D. Kim, B. Yildiz, H.L. Tuller, Degradation and recovery of solid oxide fuel cell performance by control of cathode surface acidity: Case study – Impact of Cr followed by Ca infiltration. Journal of Power Sources 558 (2023) 232589.

M. Laqdiem, A.J. Carrillo, G. Dimitrakopoulos, M. Balaguer, J. Garcia-Fayos, A.F. Ghoniem, J.M. Serra,

Impact of lattice properties on the CO2 splitting kinetics of lanthanide-doped cerium oxides for chemical looping syngas production. Solid State Ionics 394 (2023) 116192.

F. Grajkowski, S. Chandra, G. Dimitrakopoulos, D. Kim, B. Yildiz, Exploring Stable and Selective Anode Materials for the Electrochemical Oxidative Coupling of Methane (EOCM): A Case Study of Doped Titanates. ECS Transactions, 111 (6) 2259-2270 (2023).

D. Kim, G. Dimitrakopoulos, B. Yildiz. Controlling the Size of Au Nanoparticles on Reducible Oxides with the Electrochemical Potential. Journal of the American Chemical Society 2022, 144, 48, 21926–21938.

W. Fan, B. Wang, R. Gao, G. Dimitrakopoulos, J. Wang, X. Xiao, L. Ma, K. Wu, B. Yildiz, J. Li. Anodic Shock-Triggered Exsolution of Metal Nanoparticles from Perovskite Oxide. Journal of the American Chemical Society 2022, 144, 17, 7657–7666.

G. Dimitrakopoulos, B. Koo, B. Yildiz, A.F. Ghoniem. Highly Durable C2 Hydrocarbon Production via the Oxidative Coupling of Methane Using a BaFe0.9Zr0.1O3-δ Mixed Ionic and Electronic Conducting Membrane and La2O3 Catalyst. ACS Catalysis 2021, 11, 3638–3661.

J. Wang, J. Yang, A. Opitz, W. Bowman, R. Bliem, G. Dimitrakopoulos, A. Nenning, I. Waluyo, A. Hunt, J.-J. Gallet, B. Yildiz. Tuning Point Defects by Elastic Strain Modulates Nanoparticle Exsolution on Perovskite Oxides. Chemistry of Materials 2021, 33, 5021–5034.

G. Dimitrakopoulos, A.F. Ghoniem, B. Yildiz. In Situ Catalyst Exsolution on Perovskite Oxides for the Production of CO and Synthesis Gas in Ceramic Membrane Reactors. Sustainable Energy & Fuels 3 (2019) 2347–2355.

R.C. Schucker, G. Dimitrakopoulos, K. Derrickson, K.K. Kopeć, F. Alahmadi, J.R. Johnson, L. Shao, A.F. Ghoniem. Oxidative Dehydrogenation of Ethane to Ethylene in an Oxygen-Ion-Transport-Membrane Reactor: A Proposed Design for Process Intensification. Industrial & Engineering Chemistry Research 58 (19) (2019) 7989–7997.

A.F. Ghoniem, Z. Zhao, G. Dimitrakopoulos. Combustion Technologies for Low Carbon Energy: Fundamentals, Modeling and Reactors. Proceedings of the Combustion Institute 37 (2019) 33–56.

G. Dimitrakopoulos, R.C. Schucker, K. Derrickson, J.R. Johnson, K.K. Kopeć, L. Shao, F. Alahmadi, A.F. Ghoniem. Hydrogen and Ethylene Production Through Water-Splitting and Ethane Dehydrogenation Using BaFe0.9Zr0.1O3-δ Mixed-Conductors. ECS Transactions 80 (9) (2017) 181–190.

G. Dimitrakopoulos, A.F. Ghoniem. Developing a Multistep Surface Reaction Mechanism to Model the Impact of H2 and CO on the Performance and Defect Chemistry of La0.9Ca0.1FeO3-δ Mixed-Conductors. Journal of Membrane Science 529 (2017) 114–132.

G. Dimitrakopoulos, A.F. Ghoniem. Role of Gas-Phase and Surface Chemistry in Methane Reforming Using a La0.9Ca0.1FeO3-δ Oxygen Transport Membrane. Proceedings of the Combustion Institute 36 (2017) 4347–4354.

G. Dimitrakopoulos, A.F. Ghoniem. A Two-Step Surface Exchange Mechanism and Detailed Defect Transport to Model Oxygen Permeation Through the La0.9Ca0.1FeO3-δ Mixed-Conductor. Journal of Membrane Science 510 (2016) 209–219.

A. Hunt, G. Dimitrakopoulos, A.F. Ghoniem. Surface Oxygen Vacancy and Oxygen Permeation Flux Limits of Perovskite Ion Transport Membranes. Journal of Membrane Science 489 (2015) 248–257.

A. Hunt, G. Dimitrakopoulos, P. Kirchen, A.F. Ghoniem. Measuring the Oxygen Profile and Permeation Flux Across an Ion Transport La0.9Ca0.1FeO3-δ Membrane and the Development and Validation of a Multistep Surface Exchange Model. Journal of Membrane Science 468 (2014) 62–72.

I.S. Kavvadias, E.M. Papoutsis-Kiachagias, G. Dimitrakopoulos, K.C. Giannakoglou. The Continuous Adjoint Approach to the k-ω SST Turbulence Model with Applications in Shape Optimization. Engineering Optimization 47(11) (2014) 1523–1542.

**Conference presentations:**

H. Kytomaa, A. Wechsung, G. Dimitrakopoulos, Reducing Risk: Safety and Efficiency Considerations for Electrolyzer Integration, Masterclass Presentation, World Electrolysis North America 2024, September 2024.

A. Wechsung, G. Dimitrakopoulos, K. Hashad, T. Myers, Are Power-to-Heat Technologies Ready to Transition Your Facility?, 2024 AIChE Spring Meeting, New Orleans, 2024

D. Kim, G. Dimitrakopoulos, B. Yildiz. Controlling the Size of Au Nanoparticles on Reducible Oxides with Electrochemical Potential. 23rd International Conference on Solid State Ionics, Boston, MA, USA, July 2022.

B. Yildiz, G. Dimitrakopoulos, J. Wang, W. Fan, V. Kyriakou, A.F. Ghoniem, J. Li. Controlling the Size and Dispersion of Exsolved Catalyst Particles By Electrochemistry and By Strain. Invited talk, 237th ECS Meeting, Montreal, Canada, May 2020.

V. Kyriakou, G. Dimitrakopoulos, J. Wang, D. Neagu, M.N. Tsampas, B. Yildiz. In-Situ Exsolution of Metal Nanoparticles in Solid Oxide Cells for Efficient Syngas Generation from Steam and Carbon Dioxide. Invited talk, 237th ECS Meeting, Montreal, Canada, May 2020.

G. Dimitrakopoulos, J. Wang, R. Rothman, B. Yildiz. Comparison Between Thermochemical and Electrochemical Exsolution of Catalysts from Perovskite Oxides for Efficient Hydrogen Production Through Steam Electrolysis. Materials Research Society Conference, Boston, MA, USA, December 2019.

Y. Chen, X. Wu, G. Dimitrakopoulos, A.F. Ghoniem. Fabrication of Novel Janus Membrane for High Temperature Oxygen Separation and Water Thermochemical Reduction. Materials Research Society Conference, Boston, MA, USA, December 2019.

G. Dimitrakopoulos, A.F. Ghoniem, B. Yildiz. In situ Exsolution of Nickel Catalyst on Perovskite Oxides for the Production of CO and Synthesis Gas in Ceramic Membrane Reactors. 22nd International Conference on Solid State Ionics, PyeongChang, Korea, June 2019.

J. Wang, A. Opitz, R. Bliem, W. Bowman, X. Yao, A. Nenning, G. Dimitrakopoulos, I. Waluyo, A. Hunt, J.-J. Gallet, B. Yildiz. Uncovering Biaxial Strain Effect on Nanoparticle Exsolution for Thin-Film Perovskites. Bulletin of the American Physical Society, Boston, MA, USA, March 2019.

G. Dimitrakopoulos, A.F. Ghoniem, B. Yildiz. In-situ Exsolution of Nickel Nanoparticles for Efficient Carbon Dioxide Splitting and Methane Conversion to Syngas in Ceramic Membrane Reactors. Materials Research Society Conference, Boston, MA, USA, December 2018.

G. Dimitrakopoulos, A.F. Ghoniem, B. Yildiz. Catalyst Exsolution in Carbon Dioxide Splitting and Methane Conversion to Syngas Using Ceramic Membrane Reactors. Gordon Research Conference on Solid State Studies in Ceramics, Mount Holyoke College, South Hadley, MA, USA, August 2018.

G. Dimitrakopoulos, Z. Zhao, A.F. Ghoniem. Combustion Technologies for Low Carbon Energy: Fundamentals, Modeling and Reactors. Plenary lecture, 37th International Symposium on Combustion, Dublin, Ireland, August 2018.

G. Dimitrakopoulos, A.F. Ghoniem. Methane Partial Oxidation and Dry Reforming to Syngas Using the La0.9Ca0.1FeO3-δ Mixed-Conductor. 2017 AIChE Annual Meeting, Minneapolis, MN, USA, November

2017.

G. Dimitrakopoulos, R.C. Schucker, J.R. Johnson, K.K. Kopec, L. Shao, F. Alahmadi, K. Derrickson, A.F. Ghoniem. Hydrogen and Ethylene Production Through Water-Splitting and Ethane Dehydrogenation Using BaFe0.9Zr0.1O3-δ Mixed-Conductors. 232nd ECS Meeting, National Harbor, MD, USA, October 2017.

G. Dimitrakopoulos, Z. Zhao, M. Uddi, N. Tsvetkov, B. Yildiz, A.F. Ghoniem. Enhanced Intermediate-Temperature CO2 Splitting Using Nonstoichiometric Ceria and Ceria-Zirconia. 232nd ECS Meeting, National Harbor, MD, USA, October 2017.

G. Dimitrakopoulos, A.F. Ghoniem. Methane Partial Oxidation/Dry Reforming Using Nickel Catalyzed La0.9Ca0.1FeO3-δ Oxygen Transport Membranes. Invited talk, 13th International Conference on Catalysis in Membrane Reactors, Houston, TX, USA, July 2017.

G. Dimitrakopoulos, X. Wu, A.F. Ghoniem. Enhancing Syngas Production During Methane Reforming Using a La0.9Ca0.1FeO3-δ Ion Transport Membrane. Materials Research Society Conference, Boston, MA, USA, December 2016.

G. Dimitrakopoulos, A.F. Ghoniem. Role of Gas-Phase and Surface Chemistry in Methane Reforming Using a La0.9Ca0.1FeO3-δ Oxygen Transport Membrane. 36th International Symposium on Combustion, Seoul, Korea, August 2016.

G. Dimitrakopoulos, A.F. Ghoniem. Detailed Surface Kinetics and Charged Species Diffusion to Model the Impact of H2 and CO Oxidation on Oxygen Permeation Through La0.9Ca0.1FeO3-δ Mixed-Conductors. The 14th International Conference on Inorganic Membranes, Atlanta, GA, USA, July 2016.

**Invited Seminars:**

G. Dimitrakopoulos, A.F. Ghoniem, B. Yildiz. Improving the Production of Valuable Chemicals Using Ceramic Oxides Optimized Based on Advanced Catalysis Methods and Detailed Computational Models. Air Liquide - Paris Innovation Campus, Paris, France, January 2020.

G. Dimitrakopoulos, A.F. Ghoniem, B. Yildiz. The Concept of Catalyst Exsolution for Efficient Catalysis of Methane Partial Oxidation to Syngas and Carbon Dioxide Splitting to Carbon Monoxide. DuPont Research Center, Marlborough, MA, USA, December 2018.

G. Dimitrakopoulos, A.F. Ghoniem. Experimental Study and Modeling Analysis of Perovskites for Methane Partial Oxidation and Oxyfuel Combustion. Robert Borsch Research Center, Cambridge, MA, USA, November 2017.

G. Dimitrakopoulos, A.F. Ghoniem. Materials, Reactors and Systems for the Production of Hydrogen, Syngas and Chemicals. SABIC, Sugar Land, TX, USA, July 2017.

G. Dimitrakopoulos, A.F. Ghoniem. A Multistep Surface Exchange Mechanism and Detailed Defect Transport to Model Oxygen Permeation Through La0.9Ca0.1FeO3-δ Perovskites. Schlumberger Research Center, Cambridge, MA, USA, March 2016.

G. Dimitrakopoulos, A.F. Ghoniem. Modeling the Interaction of Gas Phase Chemistry with Surface Reactions on Ion Transport Membranes for Oxyfuel Combustion. Comsol Inc., Burlington, MA, USA, January 2015.

G. Dimitrakopoulos, A.F. Ghoniem. Carbon Capture Using Ion Transport Membranes and Oxyfuel Combustion Techniques. Exxon Mobil Upstream Research Company, Houston, TX, USA, June 2014.

**Webinars:**

H. Kytomaa, D. Anderson, A. Wechsung, G. Dimitrakopoulos, The Hydrogen Ecosystem: Risks & Opportunities, Exponent Webinar, September 12, 2024.

## Editorships & Editorial Review Boards

Guest Editor, Solid State Ionics, Special Issue Title: “Proceedings of 23rd International Conference on Solid State Ionics (SSI-23)”, Elsevier, July 2022.

Organizer of the “Energy and Fuels Conversion” Symposium, 23rd International Conference on Solid State Ionics, Boston, MA, USA, July 2022.

## Peer Reviews

ACS Applied Energy Materials

ACS Catalysis

Acta Materialia

Applied Sciences

Batteries

Catalysis Letters

Catalysts

Ceramics International

Chemical Communications

Chemical Engineering Journal

Chemical Society Reviews

Combustion and Flame

Energies

Fluids

Journal of Materials Chemistry A

Journal of Materials Chemistry C

Journal of Membrane Science

Journal of Power Sources

Langmuir

Materials

Materials Horizons

Proceeding of the Combustion Institute

Processes

Renewable Energy

Scripta Materialia

Solid State Ionics