Minghao Zhang, Ph.D.

Pritzker School of Molecular Engineering
University of Chicago
5640 S Ellis Ave, Chicago, IL 60637

Professional Preparation:

University of California, San Diego	Ph.D.	2012--2017	Materials Sci. & Engr.
Chinese Academy of Sciences	M.S.	2009--2012	Materials Chem. &Phys.
NanKai University	B.S.	2005--2009	Physics

Professional Appointments:

University of Chicago	Associate Research Professor	2024--now	Molecular Engineering
University of California, San Diego	Assistant Project Scientist	2020--2024	NanoEngineering
University of California, San Diego	Postdoctoral Scholar	2018--2020	NanoEngineering

Research Interest and Technical Skills:

a. Anionic activity and novel synthesis route of electrode materials with high energy density for advanced and post lithium-ion batteries
b. Materials metrology through multiple advanced characterizations such as SXRD, STEM/EELS, XPS, soft XAS, TXM, plasma-FIB, etc.
c. Ab initio simulation of electronic and ionic transport properties of materials for energy storage and conversion

Research and Professional Experience:

2021–present Co-PI on **Project of Composition Design, Interphase Engineering, and Direct Regeneration of Anionic Redox Based Co-Free High Energy Cathode Materials from LG Chem**, University of California, San Diego

-- Develop a composition and surface-modified Co-free $Li_{1+x}TM_{1-x}O_2$ cathode and novel electrolyte formulation to suppress full cell degradation at high voltage and temperature

-- The best combination of a high voltage electrode and electrolyte will achieve high cathode energy density (1200 Wh/kg) and long storage life (<4%/month capacity loss at room temperature storage)

2021–present Project Scientist on **Project of Developing Advanced Characterization Tools for Next Generation Energy Storage Materials Across Length Scales from Thermo Fisher Scientific**, University of California, San Diego

-- Evaluate cell designs of lithium-ion batteries and next gen batteries in 3D using different ion beam sources and laser depending on the representative volume needed

-- Atomic scale imaging of battery chemistries and interfaces and the effect of cyclic charging

2021–2023 Co-PI on **Project of Dry Coated Thick Electrode Fabrication and Optimization in Li-ion Batteries from Chemours**, University of California, San Diego

-- Novel dry battery electrode coating method that can offer extraordinary ionic and electronic conductivity for extremely thick electrode

-- Development of advanced characterization techniques, such as plasma focused ion beam and nano-computed tomography for thick electrode quality control

2020–2024 Co-PI on **Project of Developing High Energy Cathode Materials for Next-generation Li-ion Batteries from Umicore**, University of California, San Diego

-- Pin down the atomistic/molecular mechanism that determines the formation of a stable passivation cathode electrolyte interphase layer for high voltage cathode materials

-- Develop engineering strategies to produce the modified high voltage cathode materials at large scale with energy density exceeding 350 Wh/kg at cell level

2018–2021 Postdoctoral Research on **Project of Co Free Cathode Materials and Their Novel Architectures from DOE**, University of California, San Diego

-- New electrolyte formulation to suppress degradation in LNMO/graphite full cells

-- Feasibility of a Co free Li-ion cell with energy density exceeding 600 Wh/kg at cathode level

2012–2020 Graduate Research Assistant on **Project of Advanced Battery Materials Research (BMR) from DOE**, University of California, San Diego

-- Morphology controlled synthesis for Li-rich material

-- Gas-solid interface modification of oxygen activity in layered oxide cathodes

2015–2018 Graduate Research Assistant on **Project of Development of Advanced Li Rich xLi_2MO_3-(1-x)$LiMO_2$ Composite Cathode for High Capacity Li Ion Batteries from AFOSR/AOARD**, University of California, San Diego

-- Construction of atomistic models of layered composite cathode xLi_2MO_3-(1-x)$LiMO_2$

-- Determination of the optimal chemical composition for layered composite cathode xLi_2MO_3-(1-x)$LiMO_2$ and the optimal dopants for xLi_2MO_3-(1-x)$LiMO_2$ (M=Ni, Co, Mn, Ti, Al, Mo, etc.)

2015–2017 Graduate Research Assistant on **Project of Robust Affordable Next Generation Energy Storage System (RANGE) from ARPA-E**, University of California, San Diego

-- Demonstration of average voltage depression less than 95% of the Li-rich layered oxide after 100 cycles at room temperature

2015-2016 Research Assistant Internship on **Project of Advanced Short Term Research Opportunity Program**, Oak Ridge National Laboratory (ORNL)

-- *In Situ* Microscopy for Lithiation of SnS_2

-- STEM/EELS study on oxygen evolution reaction activity of layered catalyst

2011–2012 Research Assistant on **Project of Next Generation Batteries Material from Natural Science Foundation,** Chinese Academy of Sciences

-- Gradient structure based on spinel $LiNi_{0.5}Mn_{1.5}O_4$

-- Microwave approach synthesis

Selected Peer-Reviewed Journal Publications: († authors with equal contribution, * corresponding author)

1. M. Chouchane, **M. Zhang***, Y. S. Meng, et al, "*Improved rate capability for dry thick electrodes through finite elements method and machine learning coupling*", **ACS Energy Letters**, 2024, 9, 1480
2. R. Shimizu, D. Cheng, **M. Zhang***, Y. S. Meng, et al, "Elucidating dynamic conductive state changes in amorphous lithium lanthanum titanate for resistive switching devices", **Next Materials**, 2024, 2, 100102
3. B. Sayahpour, W. Li, **M. Zhang***, Y. S. Meng, et al, "Quantitative analysis of sodium metal deposition and interphase in Na metal batteries", **Energy & Environmental Science**, 2024, 17, 1216
4. D. Cheng, T. Wynn, B. Lu, **M. Zhang***, Y. S. Meng, et al, "A free-standing lithium phosphorus oxynitride thin film electrolyte promotes uniformly dense lithium metal deposition with no external pressure", **Nature Nanotechnology**, 2023, 8, 3230
5. **M. Zhang**, M. Chouchane, Y. S. Meng, et al, "*Coupling of multiscale imaging analysis and computational modeling for understanding thick cathode degradation mechanisms*", **Joule**, 2023, 7(1), 201

6. W. Yao, M. Chouchane, **M. Zhang***, Y. S. Meng, et al, "*A 5 V-class cobalt-free battery cathode with high loading enabled by dry coating*", **Energy & Environmental Science**, 2023, 16(4), 1620
7. X. Li, Q. Gu, **M. Zhang***, Y. S. Meng, Z. Liu, et al, "*Rational design of thermally stable polymorphic layered cathode materials for next generation lithium rechargeable batteries*", **Materials Today**, 2022, 61, 91
8. H. Chung, Y. Li, **M. Zhang***, Y. S. Meng, et al, "*Mitigating anisotropic changes in classical layered oxide materials by controlled twin boundary defects for long cycle life Li-ion batteries*", **Chemistry of Materials**, 2022, 34, 16, 7302
9. R. Shimizu, D. Cheng, **M. Zhang***, Y. S. Meng, et al, "*Unraveling the stable cathode electrolyte interface in all solid-state thin-film battery operating at 5 V*", **Advanced Energy Materials**, 2022, 2201119
10. B. Sayahpour, S. Parab, **M. Zhang***, Y. S. Meng, et al, *"Perspective: design of cathode materials for sustainable sodium‐ion batteries*", **MRS Energy & Sustainability**, 2022, 1
11. W. Li, D. Cheng, **M. Zhang***, Y. S. Meng, et al, *"Artificial cathode electrolyte interphase for improving high voltage cycling stability of thick electrode with Co-Free 5 V spinel oxides*", **Energy Storage Materials**, 2022, 49, 77
12. **M. Zhang**†, D. A. Kitchaev, Y. S. Meng, et al, "*Pushing the limit of 3d transition metal-based layered oxides that use both cation and anion redox for energy storage*", **Nature Reviews Materials**, 2022, 7, 522
13. Y. Li, W. Li, **M. Zhang***, Y. S. Meng, et al, "*Elucidating the effect of borate additive in high-voltage electrolyte for Li-Rich layered oxide materials*", **Advanced Energy Materials**, 2022, 2103033
14. D. Cheng, B. Lu, **M. Zhang***, Y. S. Meng, et al, *"Leveraging cryogenic electron microscopy for advancing battery design*", **Matter**, 2022, 5, 26
15. C. Yin†, Z. Wei†, **M. Zhang†**, et al, *"Structural insights into composition design of Li-rich layered cathode materials for high-energy rechargeable battery*", **Materials Today**, 2021, 51, 12
16. C. Fang, B. Lu, G. Pawar, **M. Zhang**, B. Liaw and Y. S. Meng et al, "*Pressure-tailored lithium deposition and dissolution in lithium metal batteries*", **Nature Energy**, 2021, 6, 987
17. H. S. Hirsh, B. Sayahpour, **M. Zhang***, Y. S. Meng, et al, "*Role of electrolyte in stabilizing hard carbon as an anode for rechargeable sodium-ion batteries with long cycle life*", **Energy Storage Materials**, 2021, 42, 78
18. **M. Zhang**†, B. Qiu†, et al, "*High pressure effect on structural and electrochemical properties of anionic redox-based lithium transition metal oxides*", **Matter**, 2021, 4, 164
19. Y. Li, M. J. Zuba, **M. Zhang***, Y. S. Meng*, et al, "*Regeneration of degraded Li-rich layered oxide materials through heat treatment-induced transition metal reordering*", **Energy Storage Materials**, 2021, 35, 99
20. B. Qiu†, **M. Zhang**†, et al, "*Metastability and reversibility of anionic redox-based cathode for high-energy rechargeable batteries*", **Cell Reports Physical Science**, 2020, 1, 100028
21. W. Li, Y. Cho, **M. Zhang***, Y. S. Meng*, et al, "*Enabling high areal capacity for Co-free high voltage spinel materials in next-generation Li-ion batteries*", **Journal of Power Sources**, 2020, 473, 228579
22. E. Zhao†, **M. Zhang†**, J. Liu, X. Yu, Y. S. Meng, et al, "*Local structure adaptability through multi cations for oxygen redox accommodation in Li-rich layered oxides*", **Energy Storage Materials**, 2020, 24, 384
23. H. Chung, A. Grenier, **M. Zhang***, Y. S. Meng, et al, "*Comprehensive study of a versatile polyol synthesis approach for cathode materials for Li-ion batteries*", **Nano Research**, 2019, 12, 2238
24. C. Fang, J. Li, **M. Zhang**, Y. S. Meng, et al, "*Quantifying inactive lithium in lithium metal batteries*", **Nature**, 2019, 572, 511
25. H. Hirsh, M. Olguin, H. Chung, **M. Zhang***, Y. S. Meng, et al, "*Meso-structure controlled synthesis of sodium iron-manganese oxides cathode for low-cost Na-ion batteries*", **Journal of The Electrochemical Society**, 2019, 166 (12), A2528
26. **M. Zhang**, H.D. Liu, Z. Liu, C. Fang, and Y. S. Meng, "*Modified coprecipitation synthesis of mesostructure-controlled Li-rich layered oxides for minimizing voltage degradation*", **ACS Applied Energy Materials**, 2018, 1(7), 3369

27. A. Singer, **M. Zhang**, S. Hy, et al, "*Nucleation of dislocations and their dynamics in layered oxide cathode materials during battery charging*", **Nature Energy**, 2018, 3, 641
28. J. Alvarado, M. A. Schroeder, **M. Zhang**, O. Borodin, et al, "*A carbonate-free, sulfone-based electrolyte for high-voltage Li-ion batteries*", **Materials Today**, 2018, 21(4), 341
29. **M. Zhang**†, K. Yin†, et al, "*In situ TEM observation of the electrochemical lithiation of N-doped anatase TiO_2 nanotubes as anodes for lithium-ion batteries*", **Journal of Materials Chemistry A,** 2017, 38, 20651
30. **M. Zhang**†, B. Qiu†, et al, "*Understanding and controlling anionic electrochemical activity in high-capacity oxides for next generation Li-ion batteries*", **Chemistry of Materials**, 2017, 29(3), 908
31. K. Yin†, **M. Zhang**†, et al, "*The formation of a self-assembled framework during lithiation of SnS_2, monitored by in situ microscopy*", **Accounts of Chemical Research,** 2017, 50 (7), 1513
32. X. Wang, **M. Zhang**, et al, "*New insights on the structure of electrochemically deposited lithium metal and its solid electrolyte interphases via cryogenic TEM*", **Nano Letters**, 2017, 17 (12), 7606
33. B. Qiu†, **M. Zhang**†, et al, "*Gas-solid interfacial modification of oxygen activity in layered oxide cathodes for lithium-ion batteries*", **Nature Communications**, 2016, 7, 12108
34. **M. Zhang**, A.C. MacRae, H.D. Liu, Y.S. Meng, "*Investigation of anatase-TiO_2 as an efficient electrode material for magnesium-ion batteries*", **Journal of the Electrochemical Society**, 2016, 163(10), A2368
35. **M. Zhang**, Y. Liu, Y. Xia, B. Qiu, J. Wang, Z. Liu, "*Simplified co-precipitation synthesis of spinel $LiNi_{0.5}Mn_{1.5}O_4$ with improved physical and electrochemical performance*", **Journal of Alloys and Compounds**, 2014, 598, 73
36. **M. Zhang**, J. Wang, Y. Xia, Z. Liu, "*Microwave synthesis of spherical spinel $LiNi_{0.5}Mn_{1.5}O_4$ as cathode material for lithium-ion batteries*", **Journal of Alloys and Compounds**, 2012, 518, 68

Patents and Book Chapter:

1. Y. S. Meng, W. Yao, **M. Zhang**, et al. "Multifunctional fluoropolymer for enabling ultrathick electrodes by dry formation processes for next-generation Li-ion batteries", provisional US patent, in application
2. S. Kumakura, M. Zhang, et al. "Method for manufacturing a boron treated positive electrode active material", provisional US patent, in application
3. C. H. Jo, **M. Zhang**, et al. "Positive electrode active materials particle for sulfide-based all-solid-state batteries", (PCT/US2020/0303720)
4. Y. S. Meng, **M. Zhang**, et al. "Lithium excess cathode material and co-precipitation formation method", (PCT/US2016/062067)
5. Z. Liu, **M. Zhang**, et al. "Microwave synthesis of spinel $LiNi_{0.5}Mn_{1.5}O_4$ cathode materials for lithium-ion batteries", ZL201110131062.2
6. Z. Liu, **M. Zhang**, et al. "Synthesis of anion-doped transitional metal oxide as cathode materials for lithium-ion batteries", ZL201110131082.X
7. Z. Liu, **M. Zhang**, et al. "Synthesis of cathode materials for lithium-ion batteries using transitional metal carbonate as precursor", ZL201110214273.2
8. I.-H. Chu†, **M. Zhang†**, S. P. Ong, and Y. S. Meng, "Handbook of materials modeling-battery electrodes, electrolytes, and their Interfaces", Edited by: W. Andreoni and S. Yip (Springer Nature Switzerland AG 2018)

Conferences / Presentations:

1. **M. Zhang**, H.D. Liu, C. Fang, Y. S. Meng, "*Minimize the voltage degradation in Li-rich layered oxide cathode materials by morphology control*" **Materials Research Society Meeting**, 2016, Boston, U.S., Oral presentation.
2. **M. Zhang**, A. C. MacRae, Y. S. Meng, "*Investigation of anatase-TiO_2 as an efficient electrode material for magnesium-ion batteries*" **Electrochemical Society Meeting**, 2016, San Diego, U.S., Poster presentation.

3. **M. Zhang**, H.D. Liu, C. Fang, Y. S. Meng, "*Morphological and surface structural changes during electrochemical cycling in Li-rich layered oxides for next generation Li-ion batteries*" **Materials Research Society Meeting**, 2017, Phoenix, U.S., Oral presentation.
4. **M. Zhang**, "*Advanced Microscopy and Spectroscopy for Probing and Optimizing Electrode-Electrolyte*", **DOE Annual Merit Review**, 2018, Washington DC, U.S., Poster presentation.
5. **M. Zhang**, H.D. Liu, Y. S. Meng, "*Structure and voltage recovery driven by defects elimination in Li-rich layered oxide cathode materials*" **Electrochemical Society Meeting**, 2018, Seattle, U.S., Oral presentation.
6. **M. Zhang**, M. Olguin, T. Wynn, Y. Li, Y. S. Meng, "*Advanced characterization tools for probing anionic redox in layered cathode materials*" **International Battery Association Meeting**, 2019, San Diego, U.S., Poster presentation.
7. **M. Zhang**, Y. S. Meng, "*Toward the stable and reversible lattice oxygen redox in Li-rich layered oxides*" **Electrochemical Society Meeting**, 2019, Atlanta, U.S., Postdoctoral Associate Research Award talk.
8. **M. Zhang**, Y. S. Meng, "*Development of cryogenic techniques for characterizing energy storage materials in electrochemical process*" **Microscopy & Microanalysis Meeting**, 2020, Virtual Meeting, U.S., Oral presentation.
9. **M. Zhang**, Y. S. Meng, "*Three-dimensional imaging and interface analysis of battery materials via plasma FIB-SEM*" **Electrochemical Society Meeting**, 2020, Virtual Meeting, U.S., Oral presentation.
10. **M. Zhang**, Y. S. Meng, "*Advance characterization tools to study and develop stable anionic redox for high-energy rechargeable batteries*" **Materials Research Society Meeting**, 2020, Virtual Meeting, U.S., Oral presentation.
11. **M. Zhang**, Y. S. Meng, "*Sodium-ion batteries paving the way for grid energy storage*" **Electrochemical Society Meeting**, 2021, Virtual Meeting, U.S., Oral presentation.
12. **M. Zhang**, "*Development of Cryogenic Techniques for Characterizing Energy Storage Materials in Electrochemical Process*", **International Cryo-EM Workshop for Advanced Materials**, 2022, Albuquerque, U.S., Oral presentation (Invited)
13. **M. Zhang**, "*Development of Cryogenic Techniques for Characterizing Energy Storage Materials in Electrochemical Process*", **Materials Research Society Meeting**, 2023, San Franscisco, U.S., Oral presentation (Invited)
14. **M. Zhang**, "*Recent Development on Co-free High Voltage Cathode Materials for Next-Generation Li-ion Batteries*", **International Youth Forum Materials and Future**, 2023, Virtual Meeting, China, Oral presentation (Invited)
15. **M. Zhang**, "*Three-Dimensional Imaging and Interface Analysis of Battery Materials Via Plasma FIB-SEM"*, and "*Development of Cryogenic Techniques for Characterizing Energy Storage Materials in Electrochemical Process*", **Microscopy & Microanalysis Meeting**, 2023, Minneapolis, U.S., Oral presentation (Invited)
16. **M. Zhang**,"*Development of Cryogenic Techniques for Characterizing Energy Storage Materials in Electrochemical Process*", **China Good EM seminar by ThermoFisher Scientific**, 2023, Virtual Meeting, China, Oral presentation (Invited)
17. **M. Zhang**, "*Development of Cryogenic Techniques for Characterizing Energy Storage Materials*", **Clean Energy Forum**, 2023, San Diego, U.S., Oral presentation (Invited)

Selected Awards and Synergistic Activities:

a. Battery Division Postdoctoral Associate Research Award of The Electrochemical Society (ECS), 2019, Atlanta, GA
b. Session Chair, Battery and Energy Technology Joint General Session, Electrochemical Society Meeting, 2019, Atlanta, GA
c. Symposium Organizer, Battery Student Slam, Electrochemical Society Meeting, 2021, Chicago, IL

d. Organizer and poster session coordinator for International Cryo-EM Workshop for Advanced Materials, 2022, Alburquerque, NM
e. Session Chair, Correlative and Multimodal Microscopy and Analysis, Microscopy & Microanalysis Meeting, 2023, Minneapolis, MN
f. Organizer for Clean Energy Forum, 2023, San Diego, CA
g. Proposal Reviewer for Office of Basis Energy Sciences (BES), Department of Energy (DOE)
h. Peer Reviewer >150 papers for Nature Energy, Nature Communications, Joule, Energy & Environmental Science, Angewandte Chemie, ACS Nano, Chemistry of Materials, Journal of Materials Chemistry A, Nano Energy, Carbon, Journal of Power Sources, ACS Applied Materials & Interfaces, Electrochemica Acta, RSC Advances, etc.

Teaching Experience and Guest Lecture:

a. Teaching Assistant for Energy Storage and Conversion – Nano 164 (undergrad) Nano261 (graduate)
b. Teaching Assistant for Thermodynamics of Materials – Nano148 (undergrad)
c. Teaching Assistant for Advanced Characterization for Nanosystems – Nano111 (undergrad) Nano230 (graduate)
d. Guest Lecture on "First principles computation demo and Review", "Advanced characterization for energy devices", "The First Law of Thermodynamics", "The Statistical Interpretation of Entropy", "Phase Equilibrium in a one-C System", "Phase Diagrams of Binary Systems", "Phase Transformation in Ceramics", "Introduction to X-ray Generation and Scattering Theory", "Introduction to Electron Energy Loss Spectroscopy", "Introduction to National Lab Facilities and Proposal Preparation", etc.