

# SYMPOSIUM CM4

*In Situ* Electron Microscopy of Dynamic Materials Phenomena  
April 17 - April 21, 2017

## Symposium Organizers

Dongsheng Li, Pacific Northwest National Laboratory  
Judith Yang, University of Pittsburgh  
Henry Zandbergen, Delft University of Technology  
Haimei Zheng, Lawrence Berkeley National Laboratory  
Yimei Zhu, Brookhaven National Laboratory

## Proceedings Statement

All authors are invited to submit articles based on their 2017 MRS Spring Meeting presentations to the journals in the MRS portfolio ([www.mrs.org/publications-news](http://www.mrs.org/publications-news)). Papers submitted and accepted for publication in MRS Advances ([www.mrs.org/mrs-advances](http://www.mrs.org/mrs-advances)) will be available as symposium collections. Visit the MRS/Cambridge University Press Publications Booth #100 in the Exhibit Hall to learn more, including MRS Advances print options available at special rates during the meeting week only.

\* Invited Paper

## TUTORIAL

### Introduction to Advanced Imaging and Tomography Techniques for Transmission Electron Microscopy

Monday Morning, April 17, 2017  
8:30 AM – 12:00 PM  
PCC North, 100 Level, Room 127 B

This tutorial will introduce the audience to the basics, principles and applications of two advanced TEM imaging techniques:

**8:30 AM - 8:40 AM**  
Introduction

**8:40 AM - 10:10 AM**  
Part I: **Liang Jin**

*High-Speed Direct Electron Detectors for In Situ TEM*

In contrast to the scintillator-based Charged Coupled Device (CCD) commonly used in TEM, direct electron detectors produce images directly from high energy electrons. The high sensitivity and high speed properties of these advanced detectors have provided material scientists a tool to study dynamic processes at the milliseconds time scale while maintaining spatial resolution of sub-nanometer and better. The tutorial will cover the physics of image formation, different imaging modes including electron counting, and new image processing methods for in situ observations. Applications of the technique to in situ mechanical, liquid cell and environmental TEM will be given.

**10:10 BREAK**

**10:30 AM - 12:00 PM**  
Part II: **Gang Ren**

*Three-Dimensional Electron Tomographic for Hard and Soft Materials Research*

Three-dimensional (3D) structural analysis is essential to understand the relationship between the structure and function of an object. Electron tomography (ET) is a technique that retrieves 3D structural information from a tilt series of 2D projections, and is becoming a mature technology with sub-nanometer resolution. First of all, this tutorial discusses the common basis for 3D characterization, and specifies difficulties and solutions regarding both hard and soft materials research. Additionally, the tutorial will cover overview of different experimental and computational techniques used in ET. Applications will be given in 3D structural analysis of both physical-sciences research and soft materials and biomaterials research.

Instructors

**Liang Jin**, Direct Electron, LP  
**Gang Ren**, Lawrence Berkeley National Laboratory

SESSION CM4.1: *In Situ* Characterization of Electrochemical Processing and Energy Materials

Session Chairs: Reza Shahbazian-Yassar and Chaoming Wang

Monday Afternoon, April 17, 2017

PCC North, 100 Level, Room 127 B

**1:30 PM \*CM4.1.01**

*In Situ* Transmission Electron Microscopy of Advanced Materials for Li-Ion and Na-Ion Batteries **Reza Shahbazian-Yassar**; University of Illinois at Chicago, United States.

**2:00 PM CM4.1.02**

Electric-Field Induced Dynamics and *In Situ* Core-Shell Formation of BNT-ST Piezoelectric Nanoparticles **Leopoldo Molina-Luna**; TU Darmstadt, Germany.

**2:15 PM CM4.1.03**

Understanding the Effect of Additives in Li-Ion and Li-Sulfur Batteries by Operando cc-(S)TEM **B. Layla Mehdi**; Pacific Northwest National Laboratory, United States.

**2:30 PM CM4.1.04**

Understanding the Origins of Activity through *In Situ* Annealing and Dealloying of Fuel Cell Catalysts **David Cullen**; Oak Ridge National Laboratory, United States.

**2:45 PM CM4.1.05**

Base Growth vs Tip Growth Mechanism via *In Situ* Multimodal Study of Sodium/Lithium Metal Deposition Using Electrochemical Liquid Cell **Zhiyuan Zeng**; Lawrence Berkeley National Laboratory, United States.

**3:00 PM BREAK**

**3:30 PM \*CM4.1.06**

*In Situ* TEM Probing of Structural and Chemical Evolution of Energy Materials—Rechargeable Batteries and Fuel Cells **Chongmin N. Wang**; Pacific Northwest National Laboratory, United States.

**4:00 PM CM4.1.07**

*In-Liquid* Observation of Electrodeposition Processes Using *In Situ* Transmission Electron Microscopy **Leyla Soleymani**; McMaster University, Canada.

**4:15 PM CM4.1.08**

Redox Mechanism Differences in Copper Systems Studied via *In Situ* TEM and Atomistic Simulations **Judith C. Yang**<sup>1,2</sup>; <sup>1</sup>University of Pittsburgh, United States; <sup>2</sup>University of Pittsburgh, United States.

**4:30 PM CM4.1.09**

Effect of Structural Order on Pulsed Laser Crystallization Kinetics of Amorphous Germanium Thin Films **Tian T. Li**; Lawrence Livermore National Lab, United States.

SESSION CM4.2: Liquid and Gas Environmental TEM Methods, Advances and Applications

Session Chairs: Dongsheng Li and Haimei Zheng

Tuesday Afternoon, April 18, 2017

PCC North, 100 Level, Room 127 B

**1:30 PM \*CM4.2.01**

Physical Chemistry of Nanocrystals with the Graphene Liquid Cell **A. Paul Alivisatos**; Lawrence Berkeley National Laboratory, United States.

**2:00 PM CM4.2.02**

Single-Particle Mapping of Non-Equilibrium Nanocrystal Transformations Using *In Situ* Liquid Cell TEM Imaging **Xingchen Ye**; University of California, Berkeley, United States.

**2:15 PM CM4.2.03**

Probing Dynamics of the Solid-Liquid Interface with *In Situ* Scanning Transmission Electron Microscopy **Ryan Hufschmid**; University of Washington, United States.

2:30 PM CM4.2.04

**Understanding Interaction of Anode Materials in Lithium Ion Batteries through *In Situ* Transmission Electron Microscopy** Hyun-Wook Lee; Ulsan National Institute of Science and Technology, Korea (the Republic of).

2:45 PM CM4.2.05

**Imaging Gas Bubble Evolution During Water Heating and Electrolysis with High-Speed Transmission Electron Microscopy** John Vance; University of Illinois at Urbana-Champaign, United States.

3:00 PM BREAK

3:15 PM \*CM4.2.06

**Visualizing Solution Based Nanofabrication Processes** Utkur Mirsaidov; National University of Singapore, Singapore.

3:45 PM CM4.2.07

**Exploring Metal Oxide Nanostructure Synthesis Mechanisms Using *In Situ* TEM** Lei Yu; University of Kentucky, United States.

4:00 PM CM4.2.08

**Experimental Design for *In Situ* Measurements in a Liquid Electrochemical TEM Holder Cell** Stephen Maldonado; University of Michigan, United States.

4:15 PM CM4.2.09

**Comment on *In Situ* (Scanning) Transmission Electron Microscopy Study of Liquid Samples** Nan Jiang; Arizona State University, United States.

4:30 PM CM4.2.10

**Fabrication of Integrated Liquid Specimen for Transmission Electron Microscopy** Wei Huan Tsai; National Chiao Tung University, Taiwan.

4:45 PM CM4.2.11

**Formation of Hollow Structures during Galvanic Replacement of Ag Nanocubes by Au Studied with Liquid Cell TEM** See Wee Chee; National University of Singapore, Singapore.

SESSION CM4.3: Poster Session

Tuesday Afternoon, April 18, 2017

8:00 PM - 10:00 PM

Sheraton, Third Level, Phoenix Ballroom

CM4.3.01

**Nucleation and Growth Analysis of *In Situ* Electrochemical Deposition of Poly(3,4-ethylenedioxythiophene) (PEDOT)** Vivek Subramanian; University of Delaware, United States.

CM4.3.02

**Transmission Electron Microscope Beam-Induced Delithiation of Lithiated Metal Silicate** Frederic Voisard; McGill University, Canada.

CM4.3.03

***In Situ* Observation of High Temperature CO<sub>2</sub> Capture over Eutectic Mixture Promoted Magnesia-Based Composites** Soonha Hwang; Myongji University, Korea (the Republic of).

CM4.3.04

**Solid Phase Crystallization of High Mobility Transparent Conducting Oxide** Sebastian Husein; Arizona State University, United States.

CM4.3.05

***In Situ* Calcination of Palladium Nanoparticles on Delta Alumina versus Ex-Situ Calcination** Siddardha Koneti; MATEIS, INSA de Lyon, France.

CM4.3.06

***In Situ* TEM Environmental Cell Optimized for EDS Studies** Julio A. Rodriguez Manzo; Hummingbird Scientific, United States.

CM4.3.07

**A Modelling Approach to Determine Gas and Temperature Profiles during Catalytic Reactions in Environmental Transmission Electron Microscopy** Jayse Langdon; Arizona State University, United States.

CM4.3.08

**Addressing *In Situ* TEM Challenges Using Integrated Hardware and Software** Benjamin Miller; Gatan, Inc., United States.

CM4.3.09

**Characterizing the Effects of Grain Size on Electron Beam Induced Artifacts during *In Situ* TEM Deformation of Al Films** Rohit Sarkar; Arizona State University, United States.

CM4.3.10

***In Situ* Observation of Au Nanoparticles Nucleation and Growth on Ultrathin MoS<sub>2</sub> Substrate** Boao Song; University of Illinois at Chicago, United States.

CM4.3.11

***In Situ* Crystallization of YIG Thin Films on Non-Garnet Substrates** Thomas E. Gage; University of Minnesota, United States.

SESSION CM4.4: Gas Environmental TEM and Imaging of Beam Sensitive Materials

Session Chair: Peter Crozier

Wednesday Morning, April 19, 2017

PCC North, 100 Level, Room 127 B

8:30 AM \*CM4.4.01

***In Situ* Environmental TEM of Carbon Nanotube Oxidation, Molybdenum Sulphide Hydrogenation and the Influence of an Imaging Electron Beam** Robert Sinclair; Stanford University, United States.

9:00 AM CM4.4.02

**The Role of Graphene in Mitigating Electron Beam-Induced Damage in Liquid Phase Electron Microscopy Investigated Using DNA-AuNP Conjugates** Hoduk Cho; University of California, Berkeley, United States.

9:15 AM CM4.4.03

**The Low-Energy Electron Beam Does Not Damage Carbon Nanomaterials** Jae Hong Choi; Ulsan National Institute of Science and Technology (UNIST), Korea (the Republic of).

9:30 AM \*CM4.4.04

**Imaging Beam-Sensitive Nanostructures by Transmission Electron Microscopy** Yu Han; KAUST, Saudi Arabia.

10:00 AM BREAK

SESSION CM4.5: Gas Environmental TEM and Catalysis

Session Chair: Yu Han

Wednesday Morning, April 19, 2017

PCC North, 100 Level, Room 127 B

10:30 AM \*CM4.5.01

**Heat, Light and Electric Field Stimuli in the Environmental TEM** Peter A. Crozier; Arizona State University, United States.

11:00 AM \*CM4.5.02

**Time Resolved Measurements to Reveal Atomic Scale Reaction Pathways Under Non-Equilibrium Conditions** Renu Sharma; National Institute of Standards and Technology, United States.

11:30 AM CM4.5.03

**Aberration-Corrected Environmental TEM Investigation of Ag Catalyzed Oxidation of Carbon Nanotubes** Datong Yuchi; Arizona State University, United States.

11:45 AM CM4.5.04

**Cathodoluminescence Characteristics of Stacking Faults in Semipolar InGaN/GaN Quantum Wells Structure** Mi-Hyang Sheen; Seoul National University, Korea (the Republic of).

SESSION CM4.6: *In Situ* TEM of Nucleation, Growth and Assembly in a Liquid Phase

Session Chairs: Utkur Mirsaidov and Haimei Zheng  
Wednesday Afternoon, April 19, 2017  
PCC North, 100 Level, Room 127 B

SESSION CM4.8: Atmospheric Pressure TEM

Session Chair: Judith Yang  
Thursday Morning, April 20, 2017  
PCC North, 100 Level, Room 127 B

1:30 PM \*CM4.6.01

**Liquid-Phase TEM Investigations of Nucleation** James J. De Yoreo; Pacific Northwest National Laboratory, United States.

2:00 PM CM4.6.02

**The Control of pH over Au Nanocrystal Growth—From Classical to Non-Classical Pathways** Guomin Zhu<sup>1,2</sup>; <sup>1</sup>University of Washington, United States; <sup>2</sup>Pacific Northwest National Laboratory, United States.

2:15 PM CM4.6.03

**Real Time Liquid Phase TEM Observations of Chain-Like and Rod-Like ZnO Formation via Oriented Attachment** Lili Liu<sup>1,2</sup>; <sup>1</sup>Pacific Northwest National Laboratory, United States; <sup>2</sup>Texas Tech University, United States.

2:30 PM BREAK

3:30 PM \*CM4.6.04

**Colloidal Nanostructures—*In Situ* Electron Microscopy of Plasmon-Mediated Synthesis, Chemistry and Self-Assembly** Eli Sutter; University of Nebraska—Lincoln, United States.

4:00 PM CM4.6.05

***In Situ* TEM Observation of New Biomineralization Pathways in Calcium Phosphate Crystals** Kun He; University of Illinois at Chicago, United States.

4:15 PM CM4.6.06

**Studying Polymer Self-Assembly by Combined Liquid Phase and Cryogenic Transmission Electron Microscopy** Joseph P. Patterson; Eindhoven University of Technology, Netherlands.

4:30 PM CM4.6.07

**A Time-Resolved View of Protein Aggregates in Pharmaceutical Formulations Using *In Situ* Liquid Cell Transmission Electron Microscopy** Madeline J. Duker; Protochips, Inc., United States.

4:45 PM CM4.6.08

**Probing Ferroelectric/Ferroelastic Nanodomain Structures at Atomic Resolution with *In Situ* TEM** Yu Deng; Nanjing University, China.

SESSION CM4.7: *In Situ* TEM of Mechanical Properties

Session Chair: Qian Yu  
Thursday Morning, April 20, 2017  
PCC North, 100 Level, Room 127 B

8:15 AM CM4.7.01

**Quantified *In Situ* TEM Tensile Test Experiments on Ni Thin Films Prepared by New Optimised Techniques** Valid Samacaghmiyoni; University of Antwerp, Belgium.

8:30 AM \*CM4.7.02

***In Situ* TEM Study of the Mechanical Behavior of Submicron-Sized Si** Zhiwei Shan; Xi'an Jiaotong University, China.

9:00 AM CM4.7.03

***In Situ* High Strain Rate Mechanical Testing in the Dynamic TEM** Thomas Voisin<sup>1,2</sup>; <sup>1</sup>Lawrence Livermore National Laboratory, United States; <sup>2</sup>Johns Hopkins University, United States.

9:15 AM CM4.7.04

***In Situ* Tensile and Fatigue Tests on Mild Notched Oligocrystalline 316L Wires** Bojan Mitevski<sup>1,2</sup>; <sup>1</sup>University of Duisburg-Essen, Germany; <sup>2</sup>BTU Cottbus-Senftenberg, Germany.

9:30 AM \*CM4.7.05

***In Situ* TEM Deformation of Lightweight Alloys and Local Strain Measurements with Diffraction Imaging** Andrew M. Minor<sup>1,2</sup>; <sup>1</sup>University of California, Berkeley, United States; <sup>2</sup>Lawrence Berkeley National Laboratory, United States.

10:00 AM BREAK

10:30 AM \*CM4.8.01

**Transmission Electron Microscopy with Atomic Resolution at Atmospheric Pressure** Xiaoqing Pan<sup>1,2</sup>; <sup>1</sup>University of California, Irvine, United States; <sup>2</sup>University of California, Irvine, United States.

11:00 AM CM4.8.02

**Study of Copper Nanocrystal Redox at Atmospheric Pressure by *In Situ* TEM** Yuzi Liu; Argonne National Laboratory, United States.

11:15 AM CM4.8.03

**Unveiling the Atomistic Processes of the Accelerated Decomposition of Y<sub>2</sub>O<sub>3</sub>-Stabilized ZrO<sub>2</sub> by Environmental TEM** Benjamin Butz<sup>1,3</sup>; <sup>1</sup>Stanford University, United States; <sup>2</sup>Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany.

11:30 AM CM4.8.04

***In Situ* TEM Monitoring of Growth Dynamics of Nanocrystalline Molybdenum Carbide Nanosheet** Ziyuan Lin; The Hong Kong Polytechnic University, Hong Kong.

11:45 AM CM4.8.05

**Structural Phase Transitions and Dynamics of Solid-Supported Interfacial Assemblies** Ding-Shyue (Jerry) Yang; University of Houston, United States.

SESSION CM4.9: Advanced *In Situ* Methods, Multimodal Characterization and Data Processing

Session Chair: Huolin Xin  
Thursday Afternoon, April 20, 2017  
PCC North, 100 Level, Room 127 B

1:30 PM \*CM4.9.01

**Using Real Time Characterization Methods to Understand Surface Phase Transitions in Layered Oxide Cathode Materials** Eric A. Stach; Brookhaven National Laboratory, United States.

2:00 PM CM4.9.02

***In Situ* Imaging with Electrons and X-Rays to Track the Conversion of Organic Inorganic Perovskite Solar Cells** Jeffery A. Aguiar<sup>1,2,3</sup>; <sup>1</sup>Idaho National Laboratory, United States; <sup>2</sup>National Renewable Energy Laboratory, United States; <sup>3</sup>University of Utah, United States.

2:15 PM CM4.9.03

**Dynamic XPS Measurements for Observing and Monitoring Surface Reactions** Christian Kaiser; Sigma Surface Science GmbH, Germany.

2:30 PM CM4.9.04

**Evolution of Electronic Structure on Transition Metal and Transition Metal Doped Titanium Disulphide by High Resolution Photoemission Spectroscopy Study** Xiaoyu Cui; Canadian Light Source, Canada.

2:45 PM CM4.9.05

***In Situ* Probing of Surface States on Nanoparticles** Qianlang Liu; Arizona State University, United States.

3:00 PM BREAK

3:30 PM \*CM4.9.06

**5D Imaging of Multi-Element and Multi-Valence Material Evolution in *In Situ* Environmental TEM by On-the-Fly and Analytical Electron Tomography** Huolin L. Xin; Brookhaven National Lab, United States.

4:00 PM CM4.9.07

**Rapid Tomography in Environmental TEM—Solutions for a Fast Analysis of Nano-Materials in 3D under *In Situ* Conditions** Siddardha Koneti; Univ Lyon, INSA-Lyon, France.

4:15 PM CM4.9.08

***In Situ* STEM-EELS Study on Cation Exchange Reactions at Nanoscale** Alberto Casu; King Abdullah University of Science and Technology, Saudi Arabia.

4:30 PM CM4.9.09

**Big Data Analytics for Scanning Transmission Electron Microscopy Ptychography** [Alex Belianinov](#); Oak Ridge National Laboratory, United States.

4:45 PM CM4.9.10

**In Situ EBSD Investigation of Cold Rolling Reduction Effect on Microstructure and Texture Evolution during Recrystallization of Commercial Pure Aluminum Alloy** [Khaled F. Adam](#); WSU, United States.

SESSION CM4.10: *In Situ* TEM of Nanostructured Materials

Session Chairs: Dmitri Golberg and Litao Sun

Friday Morning, April 21, 2017

PCC North, 100 Level, Room 127 B

8:30 AM CM4.10.01

**In Situ Electron Beam Amorphization of Sb<sub>2</sub>Te<sub>3</sub> Nano-Confined Phase Change Material within Single Walled Carbon Nanotubes** [Jeremy Sloan](#); University of Warwick, United Kingdom.

8:45 AM \*CM4.10.02

**Nanotube, Nanowire and Nanosheet Manipulations and Physical Property Analysis in a High-Resolution TEM** [Ovidiu Cretu](#); National Institute for Materials Science, Japan.

9:15 AM CM4.10.03

**In Situ Observation of Domain-Confined Growth of Hollow Nanocrystals** [Luping Tang](#); Southeast University, China.

9:30 AM CM4.10.04

**In Situ HRTEM Investigation of Phase Transformation from Anatase to Rutile** [Miao Song](#); Pacific Northwest National Laboratory, United States.

9:45 AM BREAK

10:15 AM \*CM4.10.05

**A Nanolab inside a TEM for Nanoresearch** [Litao Sun](#); Southeast University, China.

10:45 AM CM4.10.06

**Formation of Multi-Functional Heterostructure Nanowires through Solid-State Cation Exchanging Reaction** [Jo-Hsuan Ho](#); National Chiao Tung University, Taiwan.

11:00 AM CM4.10.07

**In Situ TEM Studies of Anisotropic Sublimation and Solid State Intercalation in Two-Dimensional Colloidal Bi<sub>2</sub>Se<sub>3</sub> and Bi<sub>2</sub>Te<sub>3</sub> Nanocrystals** [Joka Buha](#); Istituto Italiano di Tecnologia, Italy.

11:15 AM CM4.10.08

**In Situ Imaging and Spectroscopy of Carbon Deposition on a Ni/CeO<sub>2</sub> Catalyst** [Ethan Lawrence](#); Arizona State University, United States.

11:30 AM CM4.10.09

**Dynamic Observation of the Growth Behaviors in Cr<sub>3</sub>Si/Si Heterostructure Nanowires** [Wan-Jhen Lin](#); National Chiao Tung University, Taiwan.

11:45 AM CM4.10.10

**In Situ Visualization of Hydrogen-Induced Phase Transformations in Individual Palladium Nanorods** [Fariah Hayee](#); Stanford University, United States.

SESSION CM4.11: Ultra-Fast Electron Microscopy and Solid-State Materials Dynamics

Session Chairs: Chong-Yu Ruan and Yimei Zhu

Friday Afternoon, April 21, 2017

PCC North, 100 Level, Room 127 B

1:30 PM \*CM4.11.01

**Spatio-Temporal Visualization of Phonon and Plasmon Dynamics in Low-Dimensional Materials** [Giovanni M. Vanacore](#); Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland.

2:00 PM CM4.11.02

**Development of Sandia National Laboratories' In Situ Ion Irradiation Dynamic TEM** [Khalid Hattar](#); Sandia National Laboratories, United States.

2:15 PM \*CM4.11.03

**In Situ Imaging of Complex Phase Transitions in Functional Transition Metal Compounds at Ultrafast Timescales** [Chong-Yu Ruan](#); Michigan State University, United States.

2:45 PM BREAK

SESSION CM4.12: Advanced *In Situ* Methods and Multimodal Characterization

Session Chair: Liang Jin

Friday Afternoon, April 21, 2017

PCC North, 100 Level, Room 127 B

3:15 PM \*CM4.12.01

**High Performance Direct Electron Camera for In Situ TEM Imaging** [Liang Jin](#); Direct Electron, LP, United States.

3:45 PM CM4.12.02

**Direct Observation of Transversely Propagating Exothermic Processes in Nanoscale Thin Films** [Garth C. Egan](#); Lawrence Livermore National Laboratory, United States.

4:00 PM CM4.12.03

**High-Speed Observation of Reversible Phase Transformations Using a Direct Detection Camera** [Benjamin Miller](#); Gatan, Inc., United States.

4:15 PM CM4.12.04

**In Situ TEM Observation of Oxygen Vacancy Driven Structural and Resistive Phase Transitions in La<sub>2/3</sub>Sr<sub>1/3</sub>MnO<sub>3</sub>** [Sebastiaan van Dijken](#); Aalto University, Finland.