Dr. Shibabrata Basak

Group leader of in-situ Electron Microscopy group
Institute of Energy Technologies – Fundamental Electrochemistry (IET-1)
Forschungszentrum Jülich GmbH, Germany

Profile

A specialist in *in situ* electron microscopy, adept at designing in-situ TEM experiments, FIB, fabricating MEMS chips, and developing in-situ holders, my research focus is developing, understanding, and optimization of energy storage and conversion devices such as batteries, solid oxide fuel cells, low temperature water electrolysis through multimodal *in situ* electron microscopy.

- 12+ years' expertise of in situ high temperature, gas and liquid phase electrochemical TEM experiment design and conduct.
- 12+ years' of MEMS design and fabrication of *in situ* TEM and SEM devices for high temperature, liquid and gas phase electrochemical applications using electron beam and optical lithography; thin-film deposition using CVD, ALD, sputtering and evaporation; reactive ion etching and wet bench processing.
- 12+ years' proficiency in FIB; expertise include TEM lamella, FIB-SEM tomography, 3D EDS tomography, 3D TOF-SIMS.
- 8+ years' expertise in assembling, testing and material synthesis for Li-ion, Li-air, Li-S, Na-ion, aqueous Zn-ion batteries.
- 4+ years' experience in nanoparticle synthesis for optoelectronic applications.
- Experienced in international grant applications, guiding and leading group with bachelor, master, PhD, post-doctoral researchers and conference presenter.

Research Experience

Jan. 2023 - Present — **Group leader** at Institute of Energy Technologies – Fundamental Electrochemistry (IET-1, formal IEK-9), Forschungszentrum Jülich GmbH, Germany

- Leading in-situ electron microscopy (iEM) group consisting technician, master student, Ph.D.s, Post-doctoral researchers towards understanding different electrochemical mechanisms via multimodal in-situ electron microscopy. Group infrastructure includes:
  - In-situ TEM (JEOL GrandARM300 equipped with electrostatic shutter, Vortex modifications, dual EDS, sub frame imaging system, Gatan Clear View camera, Gatan GIF Continuum with K3 and Stela)
  - Cryo pole piece TEM (JEOL F200, Cold FEG, EDS, Gatan Metro camera)
  - Plasma Cryo FIB (TESCAN AMBER X equipped with EDS, EBDS, Ion beam polisher, TOF-SIMS, Cryo stage)
  - In-situ TEM holders (DENSsolutions Gas-heating-biasing, Liquid-heating-biasing. Cryo-biasing)

- In-situ SEM holders (DENSsolutions liquid, gas, heating)
- Fluorescence microscope with spectroscopy option (Zeiss LSM 980 with PICOQuant)
- Fluorescence (Leica) and optical microscopes (Zeiss)

Nov. 2020 – Dec. 2022 **ERC Marie Sklodowska-Curie Actions Fellow** at Ernst Ruska-Centre (ER-C) for Microscopy and Spectroscopy with Electrons, Forschungszentrum Jülich GmbH, Germany

- Project title: Electrochemistry of All-solid-state-battery Processes using Operando Electron Microscopy (grant number: 892916)

Nov. 2019 – Oct. 2020 **Research Scientist** at Institute of Energy and Climate – Fundamental Electrochemistry (IEK-9), Forschungszentrum Jülich GmbH, Germany

- Investigation of the sintering and charge/discharge mechanism of all-solid-state batteries via in-situ TEM.

Oct. 2017 – Oct. 2019 **Post-doctoral Research Fellow** at Storage of Electrochemical Energy, Delft University of Technology, The Netherlands

- Developed new polymer-based solid electrolytes for Li-ion and Na-ion batteries
- Visualized battery process using in-situ liquid phase and solid-state TEM study

Jan. 2017 – Sep. 2017 **Applications Scientist** at DENSsolutions B.V., The Netherlands

- Designed and performed in-situ gas-heating TEM experiments

Sep. 2011 – Dec. 2016 **Ph.D. Researcher** at Zandbergen lab, Delft University of Technology, The Netherlands

- Designed and performed in-situ battery TEM experiments
- Use TEM to characterize battery materials at nanoscale

Jul. 2014 – Sep. 2014 **Exchange Fellow** at Alivisatos group, University of California at Berkeley, USA

- Gained expertise in the fabrication of 'graphene liquid cells'

May 2009 – May 2010 **Masters' Project** at Indian Institute of Technology Kharagpur, India

- Synthesized ZnO nanoparticles suitable for optoelectronic application

Education

2011 - 2016 **Ph.D.**, Delft University of Technology, The Netherlands
Dissertation title: Making batter batteries: Understanding from macro to nano scale using electron microscopy
Supervisor: Prof. Henny W. Zandbergen

2008 - 2010 **M.Tech. in Solid State Technology**, Indian Institute of Technology Kharagpur, India
Dissertation title: ZnO Nanostructures: Optoelectronic, Biomedical and Sensor Applications
Grade: 8.5/10

2005 - 2007 **Master of Science in Physics**, Sikkim Manipal Institute of Technology, India
Dissertation title: Fabrication of Fiber optic Sensors
Grade: 8.7/10.0 (First Rank)

Major Publications

1. Park J., Cheng, N., Ge, B., Jodat, E., Karl, A., … , **Basak, S.**, Eichel, R.-A., (2024). Titanium Nitride Microelectrode: A New Candidate for In Situ Electrochemical Transmission Electron Microscopy Study, *Advanced Engineering Materials, 26, 2302146.* https://doi.org/10.1002/adem.202302146
2. Park J., Dutta, S., Sun, H., Jo, J., Karath, P., Weber, D., … **, Basak, S.**, Eichel, R.-A. (2024). Toward Quantitative Electrodeposition via In Situ Liquid Phase Transmission Electron Microscopy: Studying Electroplated Zinc Using Basic Image Processing and 4D STEM, *Small Methods, 2400081*. https://doi.org/10.1002/smtd.202400081
3. Pivak, Y., Park, J., **Basak, S.,** Eichel, R.-A., Beker, A., Rozene, A., Hugo Perez Garza, H., Sun, H. (2023). High-resolution and analytical electron microscopy in a liquid flow cell via gas purging, *Microscopy, 72, 520.* https://doi.org/10.1093/jmicro/dfad023
4. MacArthur, K. E., Polani, S., Klingenhof, M., …, **Basak, S.**, Eichel, R.-A., Strasser, P., Dunin-Borkowski, R. E., Heggen, M., (2023). Post-Synthesis Heat Treatment of Doped PtNi-Alloy Fuel-Cell Catalyst Nanoparticles Studied by In-Situ Electron Microscopy, *ACS Appl. Energy Mater. 6, 5959.* https://doi.org/10.1021/acsaem.3c00405
5. Camara, O, Xu, Q., Park, J., Yu, S., … , **Basak, S.,** Eichel, R.-A. (2023). Effect of Low Environmental Pressure on Sintering Behavior of NASICON-Type $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ Solid Electrolytes: An In Situ ESEM Study, *Cryst. Growth Des., 23, 1522.* https://doi.org/10.1021/acs.cgd.2c01098
6. **Basak, S.** Dzieciol, K., Durmus, Y. E., Tempel, H., Kungl, H., George, C., Mayer, J., Eichel, R.-A. (2022). Characterizing battery materials and electrodes via in situ/operando transmission electron microscopy, *Chem. Phys. Rev., 3, 031303.* https://doi.org/10.1063/5.0075430
7. Cheng, N., Sun, H., Beker, A. F., …, **Basak, S.**, Eichel, R.-A., Pivak, Y., Xu, Q., Hugo Perez Garza, H., Shao, Z. (2022). Nanoscale visualization of metallic electrodeposition in a well-controlled chemical environment, *Nanotechnology, 33, 445702*. https://doi.org/10.1088/1361-6528/ac83c7
8. Xu, Q., Liu, Z., Windmueller, A., **Basak, S.,** Park, J., Dzieciol, K. Tsai, C.-L., …, Eichel, R.-A. (2022). Active Interphase Enables Stable Performance for an All-Phosphate-Based Composite Cathode in an All-Solid-State Battery, *Small, 18, 2200266.* https://doi.org/10.1002/smll.202200266
9. **Basak, S.**, Tavabi, A. H., Dzieciol, K., Migunov, V., Arszelewska, V., …, Eichel, R.-A. (2022). Operando transmission electron microscopy of battery cycling: thickness dependent breaking of TiO2 coating on Si/SiO2 nanoparticles, *Chem. Commun., 58, 3130.* https://doi.org/10.1039/D1CC07172F
10. Camara, O., Mir, A. H., Dzieciol, K., Greaves, G., **Basak, S.**, … Hinks, J. A. (2021). Nanostructuring Germanium Nanowires by In Situ TEM Ion Irradiation, *Particle & Particle Systems Characterization, 38, 2100154.* https://doi.org/10.1002/ppsc.202100154
11. Guerrero, S. S. M., Durmus, Y. E., Dzieciol, K., **Basak, S.,** Temepl, H., … Eichel, R.-A. (2021). Improved Electrochemical Performance of Zinc Anodes by EDTA in Near-Neutral Zinc−Air Batteries, *Batteries & Supercaps, 4, 1830.* https://doi.org/10.1002/batt.202100116
12. Park J., Kretzschmar, A., Selmert, V., Camara, O., Kungl H., Tempel, H., **Basak, S.**, Eichel, R.-A. (2021). Structural Study of Polyacrylonitrile-Based Carbon Nanofibers for Understanding Gas Adsorption, *ACS Appl. Mater. Interfaces, 13, 46665*. https://doi.org/10.1021/acsami.1c13541
13. **Basak, S.**, Baaij, S., Ganapathy, S., George, C., Tempel, H., Kungl, H., … Eichel, R.-A. (2020). Accessing Lithium–Oxygen Battery Discharge Products in Their Native Environments via Transmission Electron Microscopy Grid Electrode, ACS Appl. Energy Mater., 3, 9509. https://doi.org/10.1021/acsaem.0c01803
14. **Basak, S.**, Migunov, V., Tavabi, A. H., George, C., Lee, Q., Rosi, P., Arszelewska, V., … Kelder, E. M. (2020). Operando Transmission Electron Microscopy Study of All-Solid-State Battery Interface: Redistribution of Lithium among Interconnected Particles, *ACS Appl. Energy Mater., 3, 5101.* https://doi.org/10.1021/acsaem.0c00543
15. Beker, A. F., Sun, H., Lemang, M., Tijn van Omme, J, Spruit, R. G, Bremmer, M., **Basak, S.,** Hugo Perez Garza, H. (2020). In situ electrochemistry inside a TEM with controlled mass transport, *Nanoscale, 12, 22192.* https://doi.org/10.1039/D0NR04961A
16. **Basak, S.**, Ganapathy, S., Malladi, S. K, Vicarelli, L., Schreuders, H., Dam, B., Kelder, E. M, Wagemaker, M., Zandbergen, H. W (2019). Designing Reliable Operando TEM Experiments to Study (De)lithiation Mechanism of Battery Electrodes, *J. Electrochem. Soc. 166, A3384.* https://doi.org/10.1149/2.0711914jes
17. Altantzis, T. , Lobato, I., Backer, A.D., Beche A., Zhang Y. , **Basak S.** , …. Bals,S.. (2019). 3D Quantification of the Facet Evolution of Pt Nanoparticles in a Variable Gaseous Environment, *Nano Lett.*, *19* (1), pp 477–481. https://10.1021/acs.nanolett.8b04303
18. **Basak, S.**, Jansen, J., Kabiri, Y., & Zandbergen, H. W. (2018). Towards optimization of experimental parameters for studying Li-O_2

battery discharge products in TEM using in situ EELS. *Ultramicroscopy*, *188*. https://doi.org/10.1016/j.ultramic.2018.03.005

19. Yu, C., Ganapathy, S., Eck, E. R. H. V., Wang, H., **Basak, S.**, Li, Z., & Wagemaker, M. (2017). Accessing the bottleneck in all-solid state batteries, lithium-ion transport over the solid-electrolyte-electrode interface. *Nature Communications*, *8*(1), 1–9. https://doi.org/10.1038/s41467-017-01187-y
20. Xu, Y., Swaans, E., Chen, S., **Basak, S.**, R. M. L. Harks, P. P., Peng, B., … Mulder, F. M. (2017). A high-performance Li-ion anode from direct deposition of Si nanoparticles. *Nano Energy*, *38*. https://doi.org/10.1016/j.nanoen.2017.06.011
21. Singh, D. P., Soin, N., Sharma, S., **Basak, S.**, Sachdeva, S., Roy, S. S., … Sun, S. G. (2017). 3-D vertically aligned few layer graphene – partially reduced graphene oxide/sulfur electrodes for high performance lithium–sulfur batteries. *Sustainable Energy Fuels*, *1*, 84–94. https://doi.org/10.1039/C7SE00195A
22. Ganapathy, S., Li, Z., Anastasaki, M. S., **Basak, S.**, Miao, X. F., Goubitz, K., … Wagemaker, M. (2016). Use of Nano Seed Crystals to Control Peroxide Morphology in a Nonaqueous Li-O_2 Battery. *Journal of Physical Chemistry C*, *120*(33), 18421–18427. https://doi.org/10.1021/acs.jpcc.6b04732
23. Ganapathy, S., Heringa, J. R., Anastasaki, M. S., Adams, B. D., Van Hulzen, M., **Basak, S.**, … Wagemaker, M. (2016). Operando Nanobeam Diffraction to Follow the Decomposition of Individual Li_2O_2Grains in a Nonaqueous Li-O2Battery. *Journal of Physical Chemistry Letters*, *7*(17), 3388–3394. https://doi.org/10.1021/acs.jpclett.6b01368
24. Xu, Y., Swaans, E., **Basak, S.**, Zandbergen, H. W., Borsa, D. M., Mulder, F. M. (2016). Reversible Na-ion uptake in Si nanoparticles. *Advanced Energy Materials*, *6*(2), 1–5. https://doi.org/10.1002/aenm.201501436
25. Garza, H. H. P., Ghatkesar, M. K., **Basak, S.**, Löthman, P., Staufer, U. (2015). Nano-workbench: A combined hollow afm cantilever and robotic manipulator. *Micromachines*, *6*(5). https://doi.org/10.3390/mi6050600
26. Ganapathy, S., **Basak, S.**, Lefering, A., Rogers, E., Zandbergen, H. W., Wagemaker, M. (2014). Improving Reversible Capacities of High-Surface Lithium Insertion Materials-the Case of Amorphous TiO2. *Frontiers in Energy Research*, *2*(November), 1–8. https://doi.org/10.3389/fenrg.2014.00053
27. Samanta, P. K., Datta, S., **Basak, S.**, Kamilya, T. (2013). Wet chemical growth of ultra-long ZnO nanoplates and their optical property. *Chemical Physics Letters*, *584*, 155–158. https://doi.org/10.1016/j.cplett.2013.08.053
28. Dutta, S., **Basak, S.**, Samanta, P. K. (2012). Enhanced photoluminescence from ZnO/ZnS core-shell structure. *Journal of Chemical Engineering and Materials Science*, *3*(2), 18–22. https://doi.org/10.5897/JCEMS11.064
29. Dutta, S., **Basak, S.**, Samanta, P. K. (2012). Tunable Photoemission from Bio Compatible ZnO Quantum Dots and Effect of PVA. *International Journal of Nanoscience*, *3*(1), 27–32.
30. Samanta, P. K., **Basak, S.**, Chaudhuri, P. R. (2011). Synthesis and characterization of chemically grown ultralong hexagonal ZnO nanotubes. *International Journal of Nanoscience*, *10*(1–2). https://doi.org/10.1142/S0219581X11007508

L'originale compilato e sottoscritto è depositato presso gli Uffici dell'Ente