Mesoscale Priority Research Direction

# 3D Mesostructured Battery Electrodes

## Opportunity

Mesostructuring of electrodes for electrochemical energy storage (batteries) offers potential to concurrently optimize electrical and ionic connectivity, and maximize the active material volume fraction. Minimization of strain induced damage, in particular in emerging high-energy density materials is a unique opportunity for mesostructured systems.

## Approach

Electrode mesostructuring can come in many forms including colloidal self-assembly and deterministic (e.g. holographic) methods. Understanding building block interactions, coupled with synthesis of building blocks with unique structures and chemistries will enable realization of advanced electrode designs. Templates that can later be removed will enable structuring of broad classes of materials.

## Meso Challenge

The challenge is to identify the architectures and materials, which might be quite different than those in use today, that take full advantage of mesoscale phenomena and functionalities, and develop scalable methods to self- or deterministically manufacture these systems.

## Impact

Mesoscale battery electrodes promise to exhibit new phenomena and functionalities from both current and emerging high-performance/low-cost energy storage materials. By optimizing diffusive transport of electrons and ions, and by enabling use of new materials the mesoscale will transform the energy storage landscape.


J. W. Long, B. Dunn, D. R. Rolison, H. S. White, *Three-dimensional battery architectures*, Chem. Rev. 104 4463 (2004)

C.K. Chan, H. Peng, G. Liu, K. McIlwrath, X.F. Zhang, R.A. Huggins, Y. Cui, *High-performance lithium battery anodes using silicon nanowires,* Nature Nanotech. 3, 31 (2008)

D. R. Rolison, R. W. Long, J. C. Lytle, A. E. Fischer, C. P. Rhodes, T. M. McEvoy, M. E. Bourg, A. M. Lubers, *Multifunctional 3D nanoarchitectures for energy storage and conversion*, Chem. Soc. Rev. 38 226 (2009)

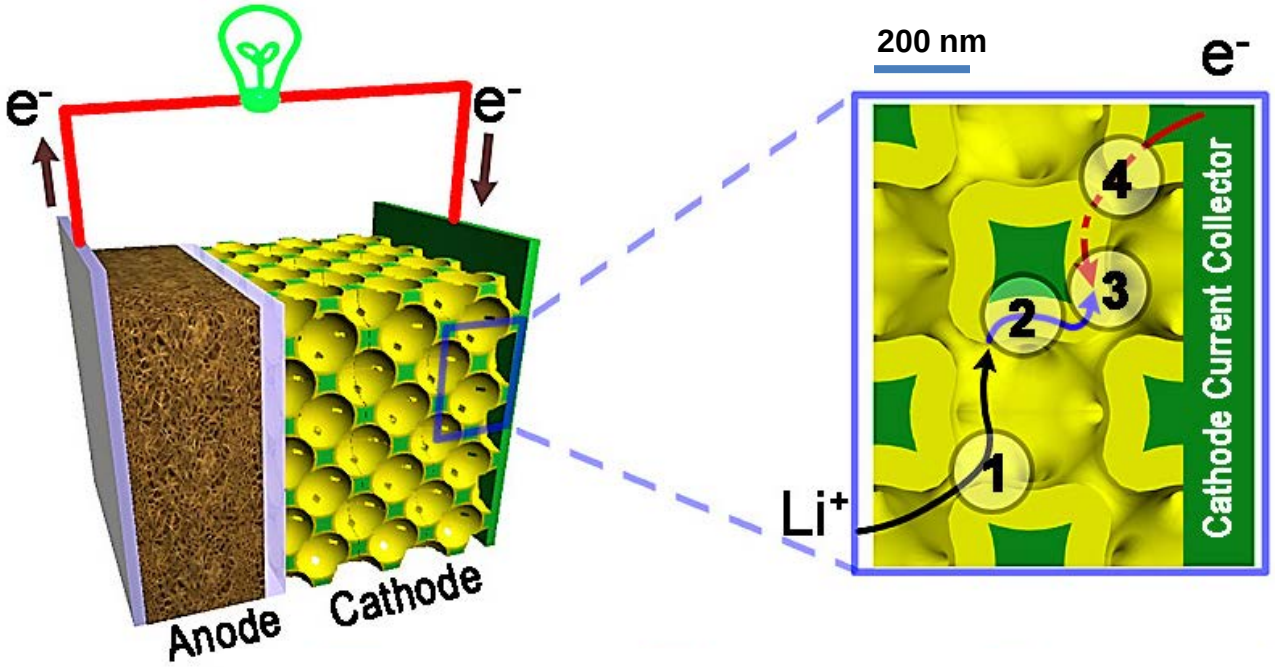
H. Zhang, X. Yu, P.V. Braun, *Three-dimensional bicontinuous ultrafast-charge and -discharge bulk battery electrodes*, Nature Nanotech. 6, 277 (2011)





Contact: Paul Braun (UIUC)

# Mesoscale Design of Battery Electrodes




## Mesoscale

1) Provides efficient ion transport
2) Results in short solid-state ion diffusion lengths
3) Generates high surface areas for electrochemical processes
4) Supports a low resistance electrical network

H. Zhang, X. Yu, P.V. Braun, *Three-dimensional bicontinuous ultrafast-charge and -discharge bulk battery electrodes*, Nature Nanotech. 6, 277 (2011)