# IOWA STATE UNIVERSITY
## Department of Mechanical Engineering

# Designing Nanomaterials and Systems to Address Critical Challenges in Energy and Sustainability


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## Abstract

One of the paramount challenges of our generation is sustaining the need for reliable and widespread energy availability without compromising sustainability of our planet. Over the past six years, my group has developed new approaches to combat some of the most difficult obstacles in energy and sustainability, often aided by the precision of nanotechnology. First I will discuss our work to study the coupling between mechanical stresses and electrochemistry in battery materials. I will highlight how the fundamental understanding gained while aiming to "strain-engineer" battery materials has opened a new pathway to redesign old battery materials into new configurations that *harvest*, instead of store energy and can be integrated into wearables for both biomechanical energy harvesting and sensing applications. Next, I will discuss key advances from my team in designing materials and systems for fast-charging, high capacity, low-cost, and multifunctional structural batteries. This includes (1) nanomaterial enabled solutions to Li-S batteries with promise of over 500 Wh/kg packaged energy density, (2) sodium batteries with engineered cycle life and cell-level cost under $75/kWh, and (3) carbon fiber reinforced structural materials which dually operate as batteries and exhibit total energy density of 35 Wh/kg. Finally, I will discuss our results focused on efficient electrochemical manufacturing of technologically valuable small diameter (< 30-40 nm) carbon nanotubes (CNTs) from $CO_2$ directly extracted from air. This technology remains the only technical approach, aided by the commercial demand and value of small diameter CNTs, which can produce a product from $CO_2$ more valuable than the cost of energy and materials required to convert it. To conclude, I will chart an ambitious path forward and place the challenges we are working to address in context of the technologies our efforts are aimed toward in my lab.


## Biography

Cary Pint is currently an Assistant Professor in the Department of Mechanical Engineering at Vanderbilt University where he has been on the faculty since July 2012. He received a B.S. in Physics from the University of Northern Iowa in 2005, and Ph.D. in Applied Physics from Rice University in 2010. Following this, he carried out a brief postdoctoral appointment at UC Berkeley and subsequently worked as a Research Scientist at Intel Labs focused on integrated energy storage technology until joining Vanderbilt as a faculty member. Cary has published ~ 115 peer reviewed journal articles in top journals such as *Nature Materials*, *Nature Communications*, *Nano Letters*, and *ACS Nano* with ~75 of these papers from his independent research team at Vanderbilt, holds 13 granted patents, and has published numerous conference papers. Cary is an Associate Editor at *Energy Storage Materials* (Elsevier) which is the highest impact journal in the area of energy storage materials/systems based on citation data. Cary is the CTO of SkyNano LLC, a company spun out from his laboratory, and a technical advisor to GridSpan Energy, a company largely inspired during a Thermodynamics course lecture. Among many national honors, Cary has been recognized as one of Forbes Magazine "top 30 under 30" disrupters in Science and Innovation, has been named as a Kavli Frontiers Fellow of the National Academy of Sciences, and was recognized by the American Society of Engineering Education (ASEE) as one of the "top 20 under 40" talent in academia.

***This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.***

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