Nanocatalysts to solve energy and environmental problems

- Developing new methods for nanoparticle synthesis using He droplets
- Utilizing new nanocatalysts to produce sustainable energy from water and CO$_2$
Calibration of large-scale traffic simulators

C. Zhang (MIT), C. Osorio (MIT), G. Flötteröd (KTH)

- Efficient estimation of demand and supply parameters of traffic simulators
- Large-scale networks: Berlin metropolitan network, with over 24,000 links, and 172,000 trips
- Algorithm reduces simulation runtime by 80%
- Of interest to transportation agencies around the world

cee.mit.edu/osorio
**Bioelectrochemical CO₂ Reduction to Chemicals:** Improved Microbial Electrosynthesis Using Gas Diffusion Electrodes

![Diagram showing the process of bioelectrochemical CO₂ reduction to chemicals using gas diffusion electrodes.](image)

- **Equation:**
  \[ 2 \text{HCO}_3^- + 9 \text{H}^+ + 8 \text{e}^- \rightarrow \text{CH}_3\text{COO}^- + 4 \text{H}_2\text{O} \]
  \[ E = -0.28 \text{ V vs SHE pH 7} \]

- **Key Points:**
  - Electricity-driven CO₂ reduction using biocatalyst
  - Homoacetogenic bacteria

**Contact:**
Dr. Deepak Pant  
[Deepak.pant@vito.be](mailto:Deepak.pant@vito.be)
CO$_2$ to chemicals/fuels

**Chemical drivers**
- A more sustainable local feedstock
- Utilize existing waste streams/exhaust
- Possibilities for new chemistry/materials

**Energy drivers**
- Peak shaving of renewable energy supplies
- Energy storage in fuels
- Less dependence on geographical location
- Public acceptance

**Novelty**

Gas diffusion electrode (GDE) instead of submerged electrode

- To enhance CO$_2$ mass transfer
- For direct CO$_2$ capture and conversion from waste gas
- To provide reducing equivalents at active sites

- Biocatalyst can access adsorbed CO$_2$, dissolved CO$_2$, and HCO$_3^-$
CO₂ ElectroRefinery

CO₂ to chemicals

Chemicals

Acetic Acid

Formic Acid

Base

Chemicals
Novel Liquid-like NOHMs-based Electrolyte for Combined CO₂ Capture and Conversion

A.-H. Alissa Park, Columbia University, New York

### Diagram

- **Waste gas**: 5 ~ 30% CO₂
- **Carbon-free electrons and H₂**
- **CO₂ conversion (e.g. electrochemical, …)**
- **Dilute CO₂ → ~100% CO₂**

### Energy

- **Capture**
- **Conversion**

### Chemicals & Fuels

- **Acrylic Acid & Acrylates**
- **CO**
- **Ethylene & Higher Hydrocarbons**
- **Formic Acid & Formates**

### Applications

- **Power**
- **Cement**
- **Steel**
Taking electrons out of bioelectronics: from bioprotonic transistors to shark’s electrosensors

Marco Rolandi, Department of Electrical Engineering
University of California Santa Cruz

Y. Deng, E. Josberger, M. Rolandi, Scientific Reports (Nature)(2013)
E. Josberger, Y. Deng, M. Rolandi, Advanced Materials (2014)
T. Miyake, M. Rolandi, APL Materials (2014)

Modeling & simulation of how automation affects vehicle-level energy, emissions, and safety outcomes, affecting larger-scale outcomes and infrastructure decisions, which can inform vehicle and engineering decisions and policy.

Costa Samaras
Carnegie Mellon University

- Mixed methods for systems engineering models under uncertainty
- Assessment along automation progression spectrum for passenger and freight mobility
- Inform robust and resilient decisions
Modeling & simulation of how automation affects vehicle-level energy, emissions, and safety outcomes, affecting larger-scale outcomes and infrastructure decisions, which can inform vehicle and engineering decisions and policy.

- Mixed methods for systems engineering models under uncertainty
- Assessment along automation progression spectrum for passenger and freight mobility
- Inform robust and resilient decisions
Chemical looping combustion (CLC) a promising technology for bio- CCS
- Lowest energy requirements of known CO₂ capture technologies
- No high-temperature corrosion risk → improves efficiency for biomass combustion
- CLC at 20 kWth scale for biomass successfully tested at VTT Bioruukki
Wireless Identification and Sensing Systems

Prof. Leena Ukkonen

- Wireless Implantable Biomedical Systems and Sensors
- Novel Materials for Wireless Identification and Sensing

RFID-inspired wireless power and data telemetry
Wearable antenna
Flexible platform
Electrodes
IC
Wearable on-body antennas
Modeling of the antenna-body interactions
→ SAR reduction

Microscopic sensing device
1 mm³

On-body transmit antenna
ASIC
Electrodes
Implant antenna
Novel applications in wireless body-centric sensing systems


Tampere University of Technology
From CO₂ to Sustainable Fuels and Chemicals

- Prof. Tejs Vegge – Technical University of Denmark (DTU)
- Computational method development for accelerated materials design
- Predicting electrocatalysts with high activity and selectivity

Solarfuels and chemicals

Computational screening

Abundance, structural complexity

Stability
Band structure
Defect tolerance
Absorptivity

More demanding calculations

Discarded materials

Candidates for experimental investigation

- From CO₂ to fuels and high-value chemicals

DTU Energy, Technical University of Denmark

Prof. Tejs Vegge, EU-US FOE 2016, Aalto University
Light-Weight Telescopes and Adaptive Optical Systems

Christopher C. Wilcox, PhD
US Naval Research Laboratory

- Light-Weight Telescopes
- Adaptive Optics for Astronomy
- Atmospheric Turbulence Studies
- Optical Interferometry
- Segmented Mirror Telescope
Hypothetical Materials Screening

High throughput screening of all conceivable porous materials for gas adsorption/separations applications, such as CO$_2$ capture.
Quantifying city-scale transport disruptions

Daniel B. Work
University of Illinois at Urbana Champaign

- Use 700 million taxi trips in New York City to measure traffic patterns.
- Events quantified in terms of duration and peak disruption.
- Uncovers new pre- and post-disaster traffic dynamics.

Hurricane Sandy
- Wed Oct 31, 2012 10 am
- JFK airport reopens
- Bus service resumes
- Traffic gridlock reported

Typical Week
- Wed Apr 18, 2012 10 am

Hurricane Sandy
(5.5 days)

Snowpocalypse
(4.4 days)

Hurricane Irene
(1.8 days)

[research sponsors: NSF & NCSA]
MESA Metamaterials Based Radar for Commercial Detect and Avoid Applications, A New Design Paradigm for Scanning Antennas

Robert T. Worl
Echodyne Corporation
- Fast Beam Scanning Radar without T/R modules
- Metamaterial Antenna Research & Production
- Focused on Bringing LIDAR like performance to Radar