

Introduction to Advanced Transportation

Fundamental research can play a role in reducing greenhouse gas emissions associated with growing global transportation energy use by enabling technologies that either significantly reduce the energy requirement of transportation or decouple vehicle energy use and emissions. Reducing the energy requirement for transportation may be accomplished by reducing vehicle mass, smoothing the operational speed profile, and reducing viscous and contact friction. Specific technical challenges in these areas include the low-cost production of high-strength, low-weight materials and the technical foundation to enable automated vehicles.

Fuel chains with low net greenhouse gas emissions include portable storage of low-carbon electricity and carbon-based fuels synthesized from low-carbon energy. Significant technical challenges in this area include developing batteries with high energy density and stability, and developing classes of low-cost catalysts capable of efficiently converting low-carbon energy into and out of forms amenable for portable storage. There are currently three active programs in this area that address the problem of electrical storage in light-duty electric vehicles.

Professors Jean-Marie Tarascon, Philippe Poizot, Michel Armand, Christine Frayret, Franck Dolhem of the University of Picardie, Jules Verne, France, are developing advanced Li-ion batteries using renewable organic electrodes. Current Li-ion battery components are not produced through renewable resources and require large amounts of energy for material extraction, processing, and end-of-life recycling. Organic materials have the potential to be used for high-performance battery electrodes with the benefit of avoiding many of the energy costs associated with processing and recovering inorganic cathode materials.

Professor Thomas of the University of Uppsala, Sweden, is exploring high specific energy lithium ion battery cathodes based on iron silicates, which are both environmentally inert and very inexpensive. Iron silicates have been shown to have high stability but low capacity. This material is being modified to accommodate additional transition metal ions that are capable of transitioning through more than one redox state and therefore incorporate more than one lithium per metal ion, raising capacity.

Professors Yi Cui and Fritz Prinz are developing high-energy-density electrodes for lithium ion batteries for electric vehicles. Close-packed, core-shell nanowire electrode architectures are being investigated as a means for using low-cost and high specific energy electrode materials – such as silicon and germanium – that would suffer from poor stability in other configurations.