The importance of electrochemical supercapacitors can be illustrated by the Ragone plot in the Figure at right. Supercapacitors occupy a niche between batteries and electrolytic capacitors, offering a higher power density but a lower energy density than rechargeable batteries, but a much higher energy density than electrolytic capacitors. For a supercapacitor powering an electric vehicle, the power density determines the possible velocity and acceleration, whereas the energy density determines how far one can travel on one charge. Their higher charge and discharge rates give supercapacitors an important role in complementing or replacing batteries in the field of energy storage, including applications such as load leveling on the electric power grid and in back-up power supplies.

Electrochemical supercapacitors include electrochemical double layer capacitors, where energy storage occurs purely by capacitive charging of a porous electrode materials (typically carbon), as well as pseudo-capacitors, where redox-active coatings onto porous electrode materials also store charge by surface or near-surface redox reactions. In Dr. Suni’s research group, we electrodeposit metal, metal oxide and metal sulfide coatings onto both planar and porous electrode materials. This allows us to compare the capacitive behavior of planar electrodes (easily accessible for surface characterization) to porous electrodes (deposited material inaccessible). For example, we recently demonstrated that electrodeposited MoS$_2$ coatings only contribute additional capacitance to a planar glassy carbon electrode up to ~50 nm, beyond which the innermost portion of the coating becomes electrically inaccessible. Our electrodeposited MoS$_2$ film have a capacitance up to 360 Farad/gram due to their small grain size.

We are also investigating a novel Al foam material, shown in Figure at left, as an alternative and inexpensive porous electrode onto which we deposit redox-active metal oxide-sulfide coatings.