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The convergence of science and engineering: Energy conversion at nano scale

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Selective mass and charge transfer drive energy conversion in any living system. Not unlike nature, man-made energy conversion systems such as fuel cells depend on membranes with selective ionic conduction.

Our experiments have shown that we can fabricate freestanding oxide membranes with a thickness of tens of nanometers. In particular, we used Yttria stabilized Zirconia and Gadolinia doped Ceria as electrolyte membranes for the creation of a new class Solid Oxide Fuel Cells (SOFCs) which are capable of operating several hundred degrees centigrade below the temperature of traditional SOFCs. First principles calculations help in understanding oxide ion incorporation and ion conductivity as a function of dopant concentration.

Our ability to effectively draw power from ultra thin membrane structures inspired us to explore interrupting the natural electron transport chain in thylakoid membranes, the key ingredient of every chloroplast organelle in light sensitive plant cells. Exposing thylakoid membrane stacks to nano-scale electrodes and stimulating them with light pulses resulted in measurable polarization currents.

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He obtained his Ph.D. in physics at the University of Vienna, Austria. His current research interests are in designing and prototyping micro and nanoscale devices for energy conversion. Examples include fuel cells and solar cells. His group studies transport phenomena across thin oxide layers and lipid bi-layers with the help of atomic force microscopy combined with impedance spectroscopy. With his students, he is synthesizing quantum dots to influence the band gap structure for improved exciton generation efficiency.