

# Integrating Super-capacitor with Solar Cell for Improved Efficiency

J. Brews (UA), D. F. Gervasio (ASU), J. Gustafson (ASU), J. Lee (Newmont Mining Co.), O. A. Palusinski (UA)

*Motivation:* Solar radiation is intermittently supplied, due to atmospheric conditions (such as clouds, temperature, transient pollution, etc.). Hence solar converters have unpredictable level of output power. This intermittency lowers the conversion efficiency because it shifts the operating point from optimum. The integration of a storage element with the solar cell mitigates undesirable power intermittency and increases conversion efficiency.

*Approach:* The storage element [1], called Digitated Energy Storage Device (DESD), employs nano-scale fabrication of metal structures that are electroplated in the pores of commercially available dielectric templates. It relies upon digitated nano-column electrodes to provide high capacitance per unit volume (Figure 1a). Fabrication involves low temperature processes, which is inexpensive, does not require clean room facilities, and does not create toxic wastes. This technology will yield DESD's that have energy densities higher than that of lithium-ion batteries. Experimental data were obtained using commercial alumina membranes with a pore diameter of 200 nm. Previously fabricated DESD prototypes achieved energy densities ( $\sim 1 \text{ Whr} / \text{kg}$ ) below that of lithium-ion batteries. Our current research has indicated ways to reach or even exceed the energy densities of most advanced batteries. This can be achieved by building DESD's using alumina membranes with higher pore density, or titania membranes, or new structures called Interdigitated Energy Storage Devices (IESD), shown in Figure 1b.

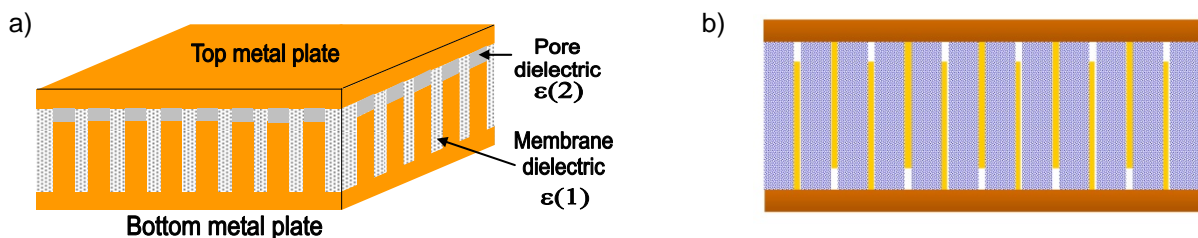


Figure 1: Schematic sketch of a DESD (a) and IESD (b) storage devices; yellow/red color metal, remainder dielectric.

Novel compatible technology for building solar cells based on nano-scale vertically integrated Schottky diodes is under development [2, 3]. The diodes are fabricated within the pores of the dielectric templates using electroplating of metal followed by silicon plating from ionic solutions.

*Intellectual merit:* Besides its practical importance in renewable energy, the work will contribute both to techniques for constructing nano-wire devices, and to developing models of devices that include new areas of physics and chemistry peculiar to nano-structures, in particular, the significant role of material interfaces where small radii of curvature influence atomic and molecular interactions.

*Impact:* The use of inexpensive, low-loss nano-scale DESD and IESD storage elements with photovoltaic devices will reduce fluctuations of output power and increase the conversion efficiency. The storage modules do not require control circuitry to prevent overcharging (a typical battery problem). The lifetime of these storage modules will be comparable to that of photovoltaics (20 years), in contrast to batteries, which may last 2 - 4 years. The broader impact will be the expansion of photovoltaic applications, especially in power networks.

## References

1. Palusinski, O. A., G. Zareba, K. Bartley, J. Lee, Z. Siwy. 2007. "Nanoscale Digitated Capacitor," US Patent Docket No. 315167US20.
2. Gervasio, D., and J. Gustafson. 2007. "Electroplating of Semiconducting Silicon", ASU Invention Disclosure, Case #: M8-042.
3. Palusinski, O. A., J. Brews, and J. Lee. 2008. "Solar Energy Conversion Device Using Nanostructured Schottky Diodes," U.S. Provisional Patent Appl. No. EB 137564025 US.