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MEMORANDUM

FROM:	Robert B. Dopp	**DATE:**	9/12/10 8:49 PM
To:	To Whom it May Concern	**# of Pages:**	2

<u>SUBJECT</u>: On-Demand Electrolyzer using GridShift Coated Electrodes

<u>ABSTRACT</u>: Onboard, on-demand electrolyzers have been used for years to enhance Internal Combustion Engines. It has been shown that the addition of small amounts of hydrogen into the fuel mixture has several documented positive effects including:

- Raising the octane number so increased compression is possible
- Improved diffusivity, particularly with the long molecules of diesel fuel oil
- Gives a very fast flame front so combustion is more complete prior to opening of the exhaust valve.
- Gives a very lean limit
- Reduces acceleration losses

Associated Challenges:

- Prone to auto ignition
- Increased exhaust temperature and therefore increase NOx.

Disadvantages can be overcome using improved injection and ignition programming. The NOx would have to be dealt with in the catalytic converter, where hydrogen addition is also beneficial.

GridShift Incorporated (GSI) has developed a way to coat nano catalysts onto a metallic surface in a way that allows excellent electrical contact to the particles while still exposing them to the electrochemical boundary layer for high efficiency and high rate water electrolysis using the automobile's electrical system or by using a secondary generator.

PRINCIPLES OF ELECTROLYSIS

Water electrolysis to produce hydrogen and oxygen is an old technology originating just weeks after Volta introduced his Pile in 1800 by William Nicholson and Anthony Carlisle. The principle chemical equations are shown below, where the electrochemical flow is shown for alkaline environments, which is the condition used in this research. The anode produces one water molecule, but the cathode consumes two, resulting in a net loss of one water and the production of one mole of hydrogen and half a mole of oxygen.

Alkaline Water Electrolysis forming Hydrogen and Oxygen Gasses

Total Reaction: $H_2O \rightarrow H_2 + 1/2O_2$

Anode ("+" Terminal): $2OH^- \rightarrow 1/2O_2 + H_2O + 2e^-$

Cathode ("-" Terminal): $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

COATING A METALLIC SURFACE WITH NANO-CATALYST

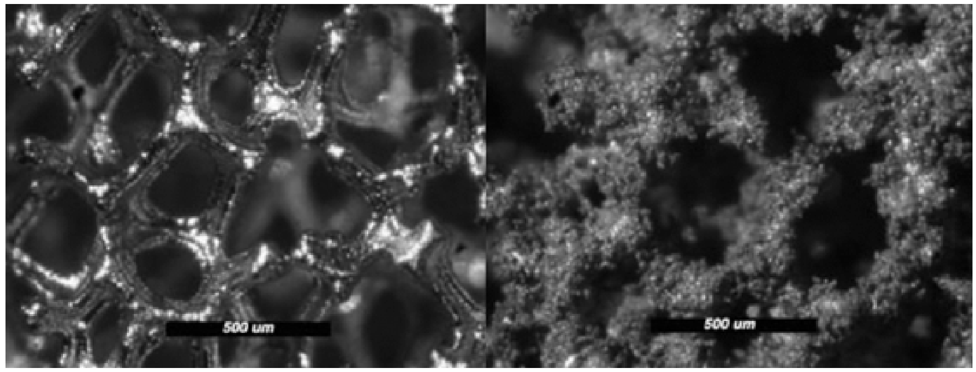

Figure 1: nano coating on a porous surface

GSI has developed a unique method to attach nano catalysts to a metallic surface in a way that has very low impedance to the reaction sites, covers all surfaces of a porous structure and leaves the particles well exposed to the electrochemical boundary layer. Many nano catalysts have been used in our experiments, with none being noble metals. At the time of this writing, we are using two catalysts in the anode (Oxygen generating) electrodes and three different catalysts in the cathode (Hydrogen generating) electrodes. The coating is uniform on all surfaces within a three-dimensional metallic surface such as metallic foam or metallic “paper” made from fibers. **Figure 1** is a comparison of an uncoated and coated porous surface. The coating extends into all internal intricacies of the porous metal substrate greatly extending the reactive surface area.

FLAT-PLATE BIFUNCTIONAL CELLS

Using this coating process, coated nickel foam panels were welded to SS316 flat-plate bifunctional electrodes. **Figure 2** shows the cell voltage of an electrolyzer using flat SS316 plates (the typical electrodes used today) and with the GSI coated plates. Also shown is the best performing bifunctional electrodes presented at the National Hydrogen Association meeting last year by a large corporation. **Figure 3** shows the same data, but recorded as Energy Efficiency. The advantage of our coating technique is unambiguous.

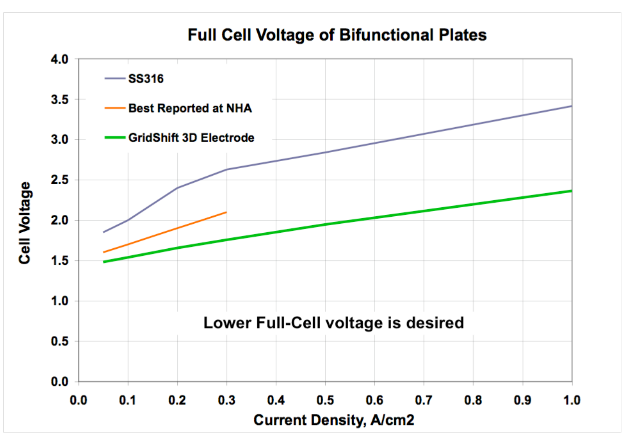

Figure 2: Bipolar Full-cell voltage

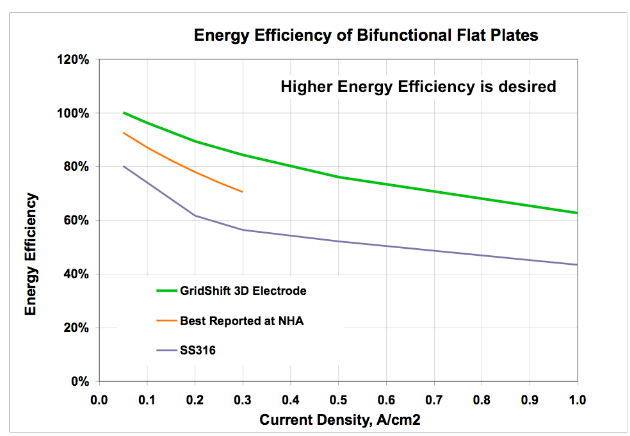

Figure 3: Bipolar Full-cell EE