APPENDIX 3: RICE UNIVERSITY REPORT

In June 2013, the CEO of FCET was invited to explore collaboration with Rice University's world-renowned Smalley Institute of Nanoscale Science and Technology in Houston, Texas. Subsequent communication took place with Dr. James Tour after it was determined that there might be both a mutual interest and a strategic advantage in collaboration between the Smalley Institute and FCET.

The Smalley Institute has chosen to apply its nanoscience resources to advance distributive energy processes, such as fuel cells, in a focused way. Because FCET is the only solid oxide fuel cell enterprise currently collaborating with the Smalley Institute, the absence of any competing fuel cell material science that might create conflicts makes it an ideal candidate for collaboration.

Richard Smalley was a visionary who foresaw the evolution of energy generation and transfer, as summarized by the following:

> *Richard Smalley's Energy Vision was The Distributed Storage-Generation Grid as he explains in his University Professor Lecture in January 2003... He saw our energy system evolving to the point where energy is transported as electricity over wires rather than physical transportation of coal, oil, etc. This Distributed Energy Grid allows for multiple energy inputs like massive solar or wind farms down to local energy generation through solar cells on rooftops. In order to see this vision become reality, the current grid infrastructure must be overhauled. (Smalley Institute)*

Fuel cells, in combination with solar, could accelerate the realization of Richard Smalley's vision. In October 2013 FCET entered into a two-year strategic partnership with Dr. Tour's group at the Smalley Institute. This work was temporarily put on hold pending successful completion of FCET's capital raise, at which time the partnership is expected to be extended through the end of 2017 and possibly into 2018. See **Appendix 3: Rice University Report.**

Dr. James Tour is world-renowned in the field of materials science and nanotechnology with more than 500 research publications and over 60 patents to his name. Additional recognition includes being named "Scientist of the Year" by *R&D Magazine*, 2013; being elected a Fellow of the American Association for the Advancement of Science (AAAS), 2009; being named one of the top 10 chemists in the world over the past decade by a Thomson Reuters citation per publication index survey, 2009; having won the Distinguished Alumni Award, Purdue University, 2009 and the Houston Technology Center's Nanotechnology Award, 2009; and having won the Feynman Prize in Experimental Nanotechnology, 2008 and the NASA Space Act Award, 2008.

Working with the preeminent group of nanotechnology scientists at Rice has been productive. FCET's competitive advantages all relate directly to its nanoscale electrolyte films and how they interface at the molecular level with anode and cathode metals and other catalytic materials and structures. Applying the Smalley Institute's world-acclaimed nanoscience expertise to FCET's basic technology should lead to additional breakthroughs for FCET in the near future.

The 2014 Fourth Quarter Report from Rice University's Smalley Institute of Nanoscale Science and Technology is reproduced here in its entirety.

2014 FCET, LLC. 4th Quarter Report

Prof. James M. Tour, Ph.D., [email redacted]

Statement of Work and Deliverables:

"This report is in compliance with the statement of work and deliverables found under Agreement No. 14-0166, Amendment No. 1:

> *Statement of Work* - Rice University will work on the development of porous metal oxides and graphene-nanotube hybrid electrodes as a starting point for improved solid oxide fuel cell performance, areas in which Rice has certain faculty, students and postdoctoral and staff scientists with knowledge and experience in substantive fields related to the Research Area. The parties, upon mutual agreement, may extend research to other areas relating to the construction or advancement of solid oxide fuel cell performance and/or a reduction of cost of its component parts or its supporting plant and equipment that may include methods involving the production of hydrogen from water or hydrocarbons, to be used for feed stock to the fuel cell.
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> *Deliverables* - A short written report, quarterly, by the Principal Investigator or his designees, outlining the various avenues of investigation, findings, and conclusions during the prior quarter, with suggestions, if any, on new areas or avenues of investigation that may bear fruit. Appended to the report should be any test results obtained by the Principal Investigator or his group on materials developed (e.g. nanotubes) that might be used to improve fuel cell performance. These tests may be conducted discretely, or when new material has been applied to an operating fuel cell, done in combination with other fuel cell components.

Intellectual Property Review

"Chance Rainwater, upon my approval, released for examination 78 patents, patents pending, and/or unpublished patent applications filed or to be filed, which were developed by my group while at Rice for examination by FCET, LLC. During our meetings with FCET's CEO, Mark Deininger, a great deal of interest was expressed in following the development of our water splitting patent application, entitled *A New Class of Hydrogen Evolution Electrocatalysts based on Nitrogen-doped Graphene Containing Small Amounts of Metal Atoms* (2015-035) and pursuing it as a possible licensing opportunity for FCET in 2015-16. I discussed with Dr. Michael Pozvonkov some other patent applications that may be useful to FCET as well. A goal for 2015-16 is to determine which of our (Tour group) patents/patents pending portfolio contain embodiments and claims that are suitable for examination and testing at Rice. FCET, LLC. Table I lists intellectual property that FCET has expressed an interest in to categorize and prioritize claims that have a high probability of success as additive materials to FCET's "POZ Cell." Coupons of these substrates will be provided by FCET for testing by my group:

Research Details

"Dr. Alexander Slesarev, a recent graduate from my group, will continue to have access to my labs as a principal scientist on this project during calendar 2015. He will serve as FCET's representative and Dr. Slesarev is to oversee the application of additive nanomaterials (nanoribbons, quantum dots, graphene containing atomic size metals, etc.) that FCET requests to be applied to their test coupons.

Test Stands (see below) have been designed and constructed by Rice in collaboration with FCET to find which additive materials will be commercially useful for the production or operation of the "POZ Cell". FCET will have an opportunity to license the rights to use the specified embodiment under prior license agreement(s) with Rice which are appended to the collaboration Agreement (No. 14-0166). To accelerate the characterization and testing of the FCET coupons using Rice's additive nanomaterials, many of which are contained in its Patents/Patents pending above, the parties have set two Test Stands:

- *Test Stand One* (TS-1): equipment supplied by Rice to conduct impedance tests for screening new materials applied to coupons, before conducting a single cell test on Test Stand Two.
- *Test Stand Two* (TS-2): equipment supplied by FCET (will be donated to Rice when construction is completed in January) was designed by Alexander Slesarev, principal scientist on this project, that has been used and will continue to be used to perform "proof of concept" characterizations as part of the screening process of these materials. TS-2 is being constructed up by Mikhail Pozvonkov (FCET's Chief Scientist) and Carter Kittrell, (Research Scientist, Smalley Institute for Nanoscale Science and Technology at Rice University). TS-2 consists of a tube oven, temperature gauge, flow meters, a power source amplifier, amp and volt meters, and software to chart the outputs and inputs during testing, plus various tubes and connective fixtures. Rice has supplied a pressure regulator, a liquid nitrogen trap for water evolution and hydrogen supply. Rice will also engineer an appropriate and sensitive device for volumetric measurement of water evolution from a single cell testing unit, and provide a high current source to remove shorts between parts of the cell by Ohmic heating (when necessary).

Once a coupon that shows results from the use of Rice's additive material(s) on TS-1 sufficient to justify building a single cell with additive materials for a TS-2 test, Dr. Slezarev will oversee the creation of another modified coupon (with a strip of uncoated coupon separating the anode and cathode sections). Once properly inserted into a glass tube or other fixture (to be provided by FCET) it will be ready for a single cell test on TS-2. TS-1 and TS-2 are designed to allow researchers to characterize the results and improvements in performance by using Rice's additive material(s). But first, a control single cell test was performed with the system.

Recent Results

"12/8/14 - Carter Kittrell monitored a test conducted on a FCET single fuel cell. This provided critical control data needed while demonstrating that TS-2 was a reliable instrument that generated results nearly identical to that obtained by a FCET test stand in Atlanta, Georgia. These results serve as a base-line or "control", to which improvements garnered through use of Rice's additive materials can be gauged. Note, these "control" single fuel cell tracked with the entries in Dr. Pozvonkov's lab notebook, ending with an electrical output of 89mA / 0.8V once the operating temperature reached 596°C. Next year (2015-16), when a single cell using Rice's additive materials shows promise of a commercial grade improvement in FCET's fuel cell assembly, then time will be devoted to building a prototype (PozCell™) incorporating Rice's additive materials into its construction. We plan to use TS-2 to see which additives provide FCET with the most substantial commercial improvements during 2015-16. A control test on an FCET PozCell™ needed to be performed to establish a base-line for these future tests.

12/9/14 - Carter Kittrell monitored the TS-2 test on the control prototype “brick”. This test measured the amount of water produced by the “brick” over a period of 2 hours and 50 minutes. The water has captured in a liquid nitrogen (LN_2) trap was 2.9 grams, which calculates into an average current of 3.8A and 0.9V (3.42W) over the 2 hour and 50 minute period at an operating temperature starting at 226°C and ending at 600°C. This data can serve as a base-line for testing Rice additives and the increase in the commercial value of the POZ Cell by combining Rice’s nanoscale technology with FCET’s technology. The results were commensurate with the results obtained by Dr. Pozvonkov in Atlanta, further demonstrating that TS-2 provides reliable data.

Conclusion

Our goal in the coming year is to partner with FCET to ultimately find true commercial value in the combining of some of our technologies with theirs. This can be realized once licenses by FCET are obtained covering specified embodiment and claims in Rice’s patents as envisioned by template license agreement(s) with Rice which are appended to the collaboration Agreement No. 14-0166.”

NOTE: Significantly, in 2015 tests were conducted on Rice’s TS-2 in which the PozCell™ set new world records for SOFC low-operating-temperature performance. At www.fcet-inc.com in the Executive Summary section, you will find a 16-minute video that shows the PozCell™ lighting up an LED lamp at 420^{0}C and then again at 350^{0}C. In 2016 in the FCET labs, the same LED lamp lit up at 260^{0}C, again setting another new world record in SOFC operating temperature performance.