PROPULSION DIRECTORATE

Monthly Accomplishment Report
October 2000

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PR SPONSORED COMPANY WINS EMERGING TECHNOLOGY AWARD: Exciton, Inc of Dayton, Ohio, recently won a prestigious Emerging Technology Award from the Ohio Department of Development's Edison Program. They received this honor, which recognizes the innovations and significant accomplishments of small technology-oriented companies in Ohio, for their work on a manufacturing process for quadricyclane, a high energy/high density rocket fuel. Under a Propulsion Directorate sponsored Phase II SBIR, Exciton developed a cost-effective photochemical process for manufacturing quadricyclane. Previous studies have demonstrated that the addition of quadricyclane to kerosene rocket fuel (RP-1) can result in a considerable increase in payload for rocket powered vehicles. Exciton is now in a position to produce up to 1000 pounds of quadricyclane per month, which is significant because quadricyclane had not previously been available in sufficient quantities to perform actual rocket engine testing. Furthermore, the new manufacturing process will lower the price of quadricyclane by an order of magnitude, from about $100/lb to $10/lb. A number of potential commercial customers for this rocket fuel have been identified. The Wright Technology Network (WTN) nominated Exciton for this award. (J. Pearce, AFRL/PRO (UTC), (937) 255-5451)

Exciton's quadricyclane processing unit

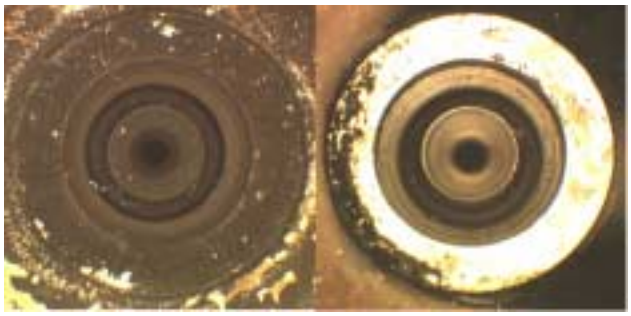
Want more information?

- A description of the Emerging Technology Award and a list of previous winners can be found at http://www.odod.state.oh.us/tech/edison/97PRO.htm.
- The Wright Technology Network's Success Story on Exciton's quadricyclane work is available at http://www.wtn.org/ss/story.phtml?storyId=20&type=Commercialization.

FUEL ADDITIVE TO EXTEND AIRCRAFT LIFE FOR RAAF: A representative of the Royal Australian Air Force (RAAF) recently visited the Propulsion Directorate to discuss implementation of the +100 thermal stability fuel additive. This additive was originally developed under a program sponsored by the Propulsion Directorate's Fuels Branch (AFRL/PRTG). The goal of the program was to develop an additive that would extend the useful operating temperature of JP-8 fuel by 100°F (thus the +100 name) through the addition of a low-cost additive package. The RAAF plans to use the +100 additive as an approach to extend the useful life of their fleet of F-111 fighter/bombers. The RAAF believes that the F-111's TF30 engines will require the +100 additive to extend their hot section life to the year 2020. The RAAF also has C-130s in their inventory that could benefit from the +100 additive. Further discussions were held between RAAF, AFRL, and San Antonio Air Logistics Center (SA-ALC) personnel to understand the latest +100 technology and implementation strategies for the additive. These discussions were held to facilitate a smooth transition to the +100 additive for the

RAAF. As well as extending aircraft life for the RAAF, the transition to +100 will assist in the interoperability of the USAF and the RAAF. (P. Pearce, AFRL/PRTG, (937) 255-6918)

RAAF F-111



F-111 engine components operated without (left) and with (right) the +100 fuel additive

PR ASSISTS B-2 SPO IN SELECTION OF MAIN AIRCRAFT BATTERY UPGRADE: Yardney Technical Products (YTP), Inc was recently selected by the Northrop Grumman (NG) B-2 OEM to supply an advanced prismatic design lithium-ion (Li-ion) battery for the B-2 Link 16 Upgrade. YTP is one of two contractors under the joint DoD/NASA Lithium-Ion Battery Initiative developing the chemistry, cells, and technology to produce these advanced batteries for aerospace applications. The DoD/NASA Lithium-Ion Battery Initiative includes significant participation by the Propulsion Directorate. As a result of this DoD/NASA Initiative and progress made on the battery for the Mars 2001 Lander Mission, YTP was able to design a first article battery for development that will meet the stringent low physical weight and volume restrictions required by the B-2. The B-2 battery is also required to operate over the temperature range of -40°C to 63°C, with a limiting high discharge capacity required at -40°C that will determine the final capacity of the battery at room temperature. The Propulsion Directorate's Battery Branch (AFRL/PRPB) provided technical support to the B-2 SPO and the OEM during concept development and source selection. The program to develop these batteries is on a very tight schedule, and YTP plans to deliver batteries to the OEM by May 2001. These batteries will then be tested at the Propulsion Directorate to validate performance and characteristics prior to EMD flight qualification testing and placement of an order for the B-2 fleet and appropriate spares. This will be the first main aircraft battery application of Li-ion technology. (J. Erbacher, AFRL/PRPB, (937) 255-7770)

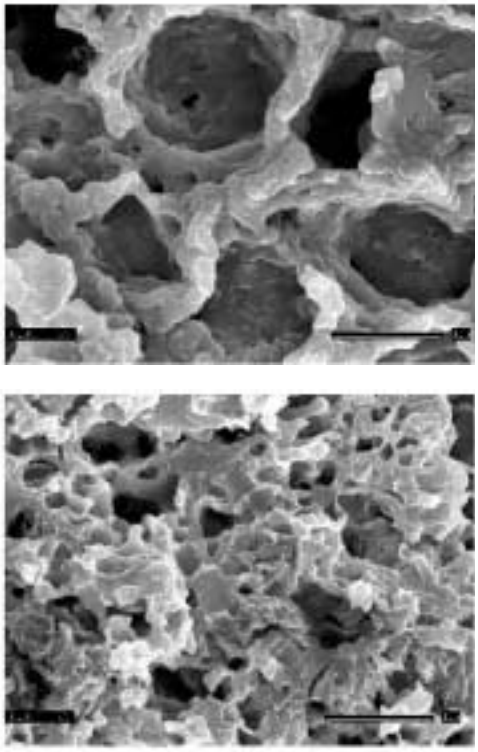
USAF B-2

FORSTER HONORED BY ASME: Dr. Nelson Forster of the Propulsion Directorate's Mechanical Systems Branch

Dr. Nelson Forster

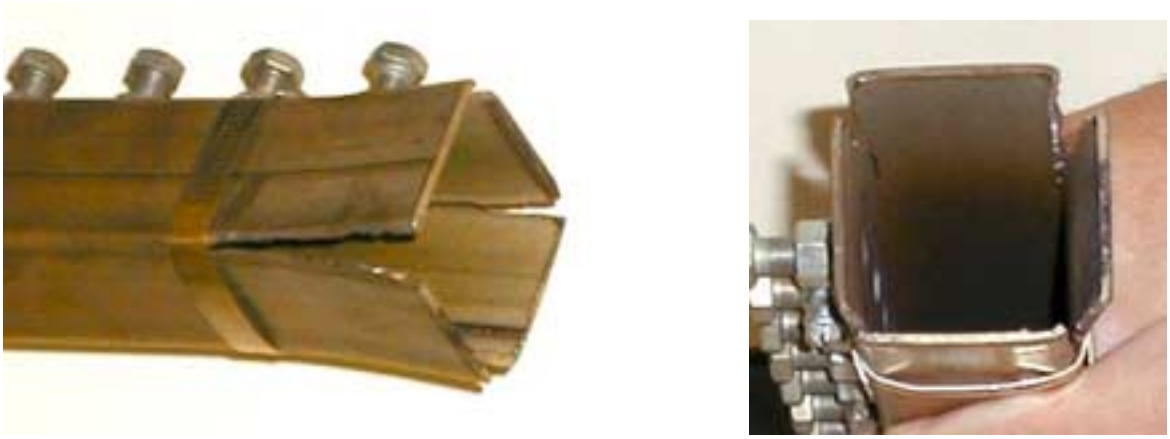
(AFRL/PRTM) was recently honored by the American Society of Mechanical Engineers (ASME). Dr. Forster was selected by ASME's Tribology Division to receive the Innovative Research Award for his work in pioneering the understanding of carbon-carbon composite tribology. ASME's Tribology Division periodically gives this award to honor a recent major contribution in tribology. Dr. Forster currently serves as the Air Force senior engineer responsible for the technical direction of research and development for mechanical and lubrication systems in gas turbine engines. He received the Innovative Research Award at the Joint Society of Tribologists and Lubrication Engineers (STLE)/ASME Annual Meeting in Seattle, Washington, on 3 October 2000. (R. Wright, AFRL/PRTM, (937) 255-5568)

POSS MICRO-FOAM PROGRAM MEETS WITH EARLY SUCCESS: The Propulsion Directorate recently initiated a 3-year Dual Use Science and Technology (DUS&T) Program with Wright Materials Research Co (WMR). The purpose of this program is to combine POSS (Polyhedral Oligomeric Silsesquioxanes) polymers with micro- and nanocellular foams. POSS polymers offer significant property enhancements, such as improved mechanical and physical properties, while micro- and nanocellular foams offer remarkable strength increases and weight reductions. Although most foams result in a decrease in the structural integrity of the material, micro-foams have increased strength and can also be made into transparent materials. One Air Force application for this material is jet canopies with increased heat distortion temperatures (HDT), increased strength, and reduced weight. Radomes with increased HDT, decreased water uptake, and lower dielectric constants and loss tangents represent another potential application for this material. Only 3 months into the program, WMR has already successfully micro-foamed POSS-PMMA for jet canopy applications. This resulted in a material with optical clarity and 50 percent reduced weight, already meeting the Phase I goals of the program. Physical and mechanical property testing of the material is currently under way. The Propulsion Directorate's Polymer Working Group is currently making POSS-Polystyrenes for micro-foaming, and POSS-PMMAs are being subjected to nano-foaming conditions. (S. Phillips, AFRL/PRSM, (661) 275-5416)



Sample foams developed under the program with WMR

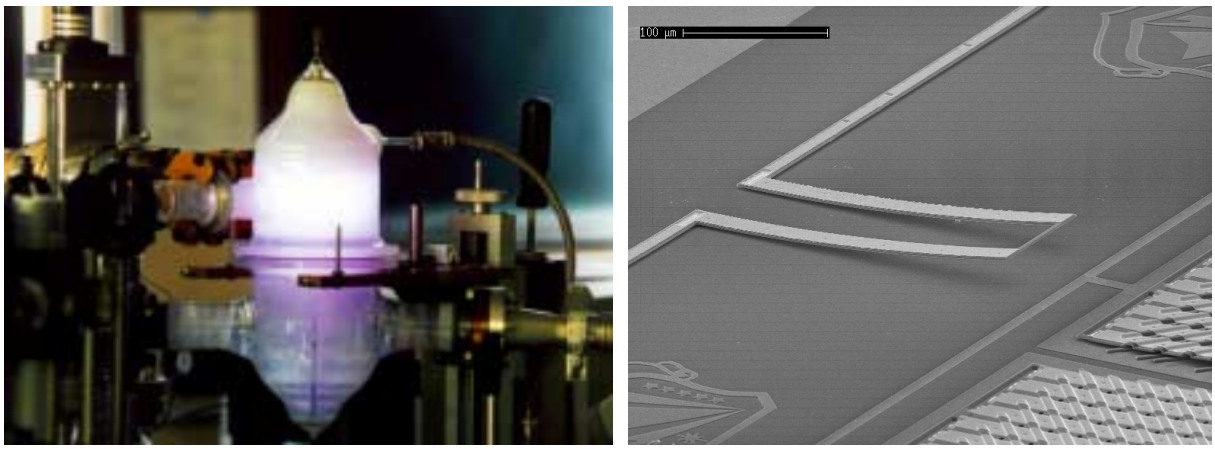
RESEARCH TO USE PRACTICAL FUELS IN PULSED DETONATION ENGINES: The Propulsion Directorate's in-house research Quad-4 based pulsed detonation engine (PDE) recently achieved a technical milestone. The in-house PDE attained a true thermal steady state with an uncooled detonation tube by using stainless steel detonator tube sections. As a result, tube wall temperatures were significantly hotter in these tests than was previously thought possible, and thrust levels did not drop off due to pre-ignition. The ability to run high temperature, uncooled detonator tubes is a significant technological stride because it allows the use of endothermic fuels, which in turn will increase the detonability of practical liquid fuels. In this testing, the detonation tubes were operated until they failed (see images). Approximately 100,000 hot detonation cycles were achieved before the onset of failure, and the ability to run an uncooled detonator tube for an extended duration is another significant finding from this work. The PDE concept holds the promise of outstanding propulsion performance from an engine that is relatively simple and cheap to manufacture. The knowledge gained from these experiments will be used to create PDE designs with more practical fuel systems, which are both lighter and more affordable. (F. Schauer and J. Stutrud, AFRL/PRTS, (937) 255-1554)



Two views of detonation tubes that were run to failure in recent testing

IN-HOUSE RESEARCH RESULTS PUBLISHED IN NASA TECH BRIEFS: The results of in-house research performed by the Propulsion Directorate's Power Division (AFRL/PRP) were recently published in *NASA Tech Briefs*. The published article discusses the optimization of anisotropic plasma etching of silicon carbide (SiC). DoD applications for this new etching technique include power devices, pressure and temperature sensors, SiC high temperature integrated circuits, high power switches, and high temperature micro-electromechanical systems (MEMS) device fabrications. This new technique significantly enhances the ability to realize SiC power electronic devices capable of satisfying More Electric Aircraft (MEA), radiation hardened electronics for space based radar (SBR), and directed energy weapons (DEW) requirements. Numerous commercial applications for this technology have also been identified in the power generation, automotive, and medical industries. The publication discusses details of the technique such as the use of gas mixture plasmas to control power deposition, self dc bias, and chemical and physical sputtering, which help to obtain high etch rate with minimal surface damage. The most significant achievements have been the development of the rf plasma reactor design and the operating parameter optimization, which have allowed in-house research researchers to obtain

both high etch rates and excellent surface planarity. This work was also published in the *Journal of Vacuum Science and Technology*. (B. Ganguly, AFRL/PRPS, (937) 255-2923)



Plasma etching apparatus (left) and a MEMS hot-wire anemometer (right)

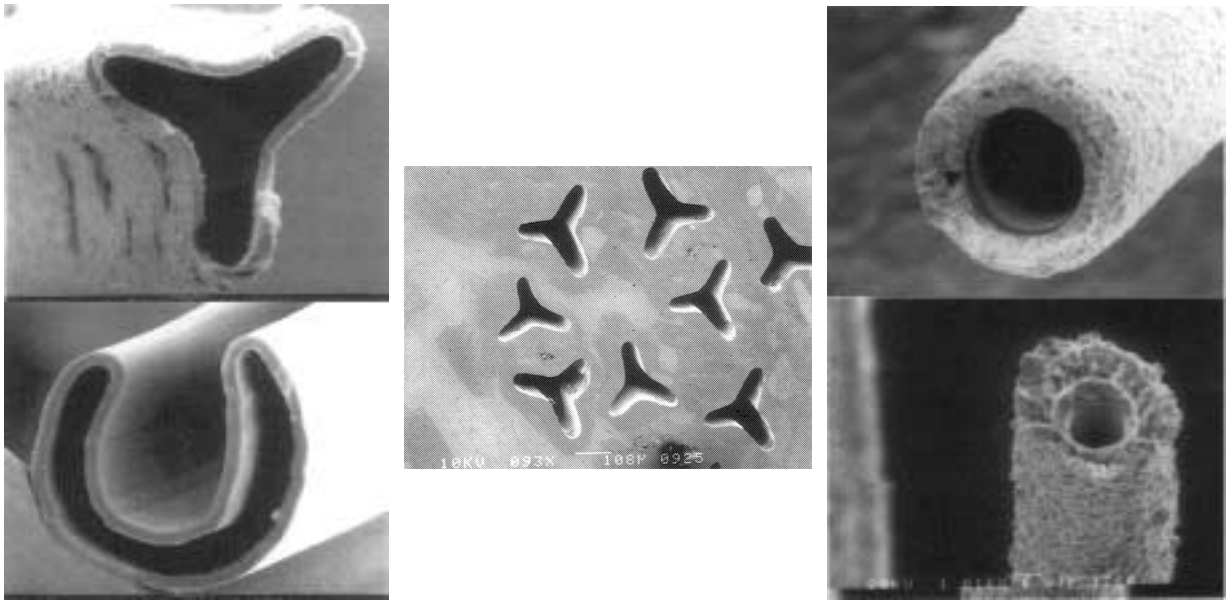
FIRST POSS WORKSHOP A BIG HIT: On 7-8 September 2000, AFRL, Hybrid Plastics, and Divex co-sponsored the first POSS (Nanostructured) Workshop in Huntington Beach, California. POSS, which is an acronym for Polyhedral Oligomeric Silsesquioxanes, is a technology of great interest because POSS additives can radically upgrade the thermal and physical properties of most plastics. Researchers in the Propulsion Directorate's Propulsion Materials Applications Branch (AFRL/PRSM) have spearheaded research efforts to develop POSS nanotechnology, which is playing an ever-increasing role in the polymer world. The goals of the workshop were: (1) to strengthen the collaboration between academic, industrial, and governmental investigators to further understanding of POSS technology, (2) to increase commercial awareness of the property enhancements and practicality of POSS, and (3) to increase the likelihood of sustainment of the technology to ensure stability for Air Force applications. The workshop attracted interest from over 75 companies, and featured research by 27 US academics and R&D work on 11 Air Force applications. The workshop was a tremendous success, and the attendees stated almost unanimously that it was one of the top workshops they had ever attended. (S. Phillips, AFRL/PRSM, (661) 275-5416)

NEW MICROTUBE PATENT ISSUED: On 5 September 2000, the Air Force was issued US Patent Number 6,113,722, titled "Microscopic Tube Devices and the Method of Manufacture." The inventors of this patent are Dr. Wesley Hoffman of the Propulsion Directorate at Edwards AFB and Dr. Phillip Wapner, an on-site contractor. This is the latest in a series of microtube patents issued to researchers at Edwards AFB. This invention describes devices composed of at least one microscopic hollow tube having a wall thickness of at least one nanometer and a diameter of at least five nanometers. The walls of the tubes can be formed from a wide variety of

materials, such as metals, polymers, carbon, ceramics, and glasses. If the space between the tubes is filled, the tubes become channels in a monolithic or composite body, and the channels can have a random or ordered orientation. In addition, the interior of the tube walls can be coated with a desired material such as a catalyst and may also have depressions or elevations therein that were imparted to the fibers upon which the tubes are formed. Numerous applications for these microtubes have been identified in the aerospace, automotive, and medical industries. Further details of the patent can be obtained from the US Patent & Trademark Office's website (see below). (W. Hoffman, AFRL/PRSM, (661) 275-5768)

Want more information?

- The text of this patent is available at the US Patent & Trademark Office's website at http://164.195.100.11/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&u=/netahtml/search-adv.htm&r=1&p=1&f=G&l=50&d=ft00&S1=6113722&OS=6113722&RS=6113722.



Samples of various microtubes covered by this patent

ULTRANARROWBAND OPO INSTALLED AT WPAFB: During the course of the past several years, the Propulsion and Sensors Directorates have been working together to foster the development of novel lasers for cross-directorate applications. An ultranarrowband optical parametric oscillator (OPO) has been developed through this cross-directorate effort via a Phase II SBIR program with Aculight Corporation in Bothell, Washington. Aculight, which has constructed only four of these advanced laser sources, recently installed two of the four at Wright-Patterson AFB, Ohio. The OPO provides tunable, single-mode output across a broad region in the near- and mid-infrared covering wavelengths from 1.1-1.4 microns and 2.2-3.7 microns. This spectral region is ideal for characterizing a number of key chemical species in combusting flowfields, including carbon monoxide, nitric oxide, methane, and water. Experiments designed to exploit the unique characteristics of these devices are currently under way. (J. Gord, AFRL/PRTS, (937) 255-7431)