PROPULSION DIRECTORATE

Monthly Accomplishment Report
July 2004

Contents ***Page***

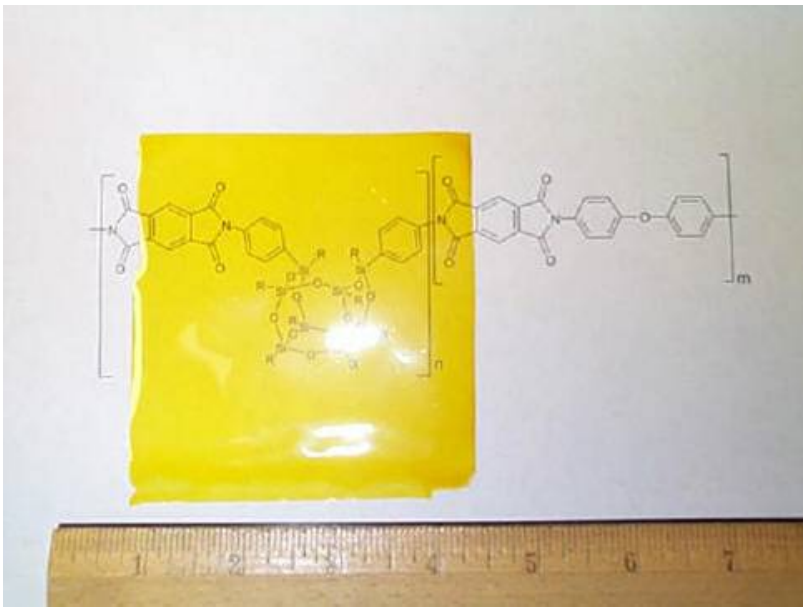
DISTRIBUTED HETEROGENEOUS SIMULATION LAB OPENS: The Propulsion Directorate's Electrical Technology and Plasma Physics Branch (AFRL/PRPE) recently established the Distributed Heterogeneous Simulation (DHS) laboratory. The facility will take advantage of the DHS techniques developed under Air Force Small Business Innovation Research (SBIR) Phase I and II projects with PC Krause and Associates, Inc. DHS allows faster, more detailed simulations of dynamical systems. The laboratory is being used to implement simulation and analysis of numerous systems of interest to the Air Force. Work is presently under way to investigate Global Hawk integrated propulsion, power, and electrical load characteristics, including advanced sensor suites such as the Multi-Platform RADAR Technology Insertion Program (M-PRTIP). The DHS laboratory capabilities will include integrated propulsion, power, thermal, avionics, sensor, and weapons research and analysis relevant to the F-35 JSF, F-22, F-16, High Altitude Airship, and various directed energy systems. (Mr. P. Lamm, AFRL/PRPE, (937) 255-4045)

The Distributed Heterogeneous Simulation (DHS) laboratory was recently established in the Propulsion Directorate

POSS-POLYIMIDE PATENT AIMS AT IMPROVED MATERIALS FOR SPACE: US Patent #6,767,930, titled "Polyhedral Oligomeric Silsesquioxane Polyimide Composites," was issued on 27 July 2004. The inventors of this patent include three Propulsion Directorate researchers: Drs. Steve Svejda, Shawn Phillips, and Rene Gonzalez. The other inventors of this patent are Prof. Frank J. Feher of the University of California-Irvine,* and Drs. Joseph D. Lichtenhan, Joseph J. Schwab, and William A. Reinerth of Hybrid Plastics. Many electronic and

* Prof. Feher was with the University of California-Irvine when the patent was filed, but now is at Goodyear.

space vehicle component designs now demand materials with improved thermal and oxidative stability relative to that offered by the current level of imide, epoxy, and ester-based polymer resins. A particular deficiency exists in the area of space resistant polymeric materials, as there are no commercially available polyimides that are resistant to degradation by atomic oxygen. This patent addresses methods for the preparation and application of POSS-polyimides,[†] including the in-situ formation of protective oxidative coatings that are being explored for space-materials by PR's Dr. Sandra Tomczak. This patent protection will be invaluable as Dr. Tomczak pursues commercialization of POSS-polyimides through a DARPA program. (Dr. S. Phillips, AFRL/PRSM, (661) 275-6270)



A sample of POSS-Kapton material

Capt Michelle E. Rauch-Johnson won the Commander's Cup Award (Individual) at the recent AFRL Corporate Awards

PR PERSONNEL CAPTURE FOUR AFRL CORPORATE AWARDS: Propulsion Directorate personnel walked away with four of the eleven awards presented at the 5th Annual AFRL Corporate Awards held in Rome, New York, on 22 July 2004. The Commander's Cup Award (Team) was given to the Battlefield Air Operations (BAO) Team. This team, which consists of personnel from several AFRL technical directorates, includes the following nine individuals from PR: Capts David A. Pfahler and William E. Notbohm; Drs. Joseph P. Fellner, Thomas L. Reitz, Kirk L. Yerkes, and Russell L. Spyker; and Messrs. Steven P. Vukson, Gary J. Loeber, and Cameron A. Riepenhoff.[‡] The Commander's Cup Award (Individual) was presented to Capt Michelle E. Rauch-Johnson. The S&T Achievement Award (Team) was presented to the Critical Pulsed Detonation Engine Experiment Team, consisting of the following individuals: Drs. Frederick R. Schauer and James R. Gord; Messrs. Dale T. Shouse and Jeffrey S. Stutrud.

[†] POSS = Polyhedral Oligomeric Silsesquioxane

[‡] Mr. Riepenhoff is an on-site contractor with Wyle Labs.

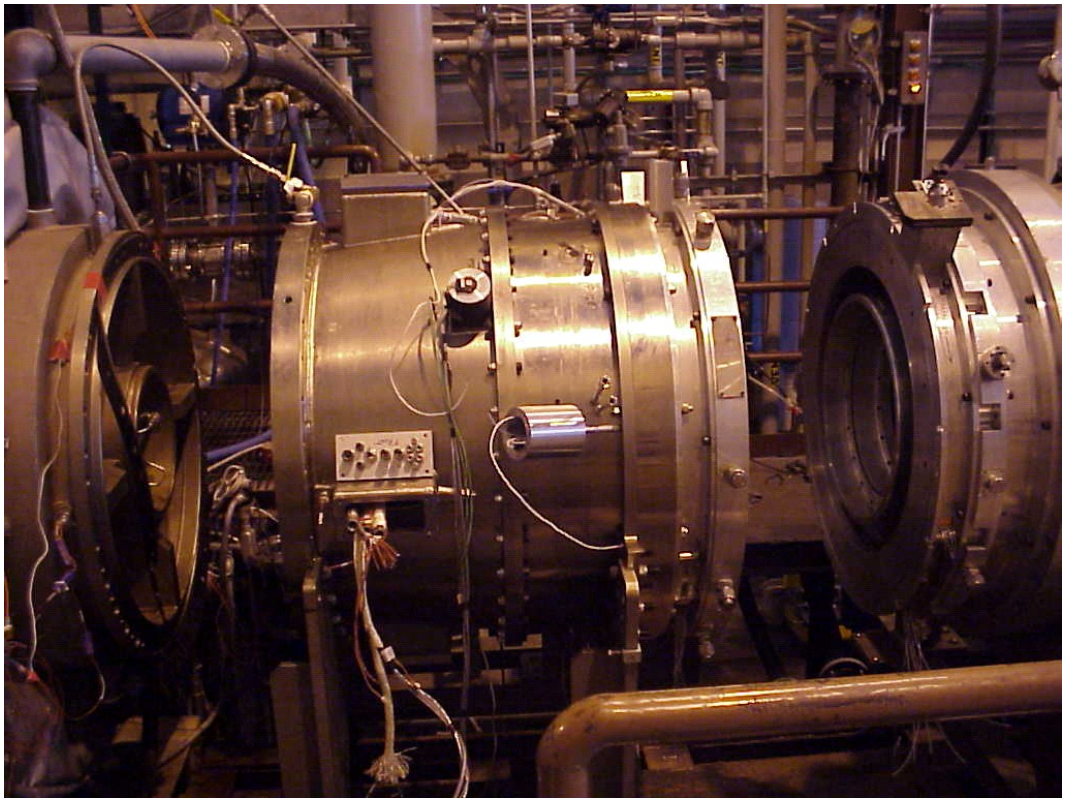
Finally, the Administrative Excellence Award (Individual) went to Ms. Chanda Smith. (Col M. Heil, AFRL/PR, (937) 255-2520)

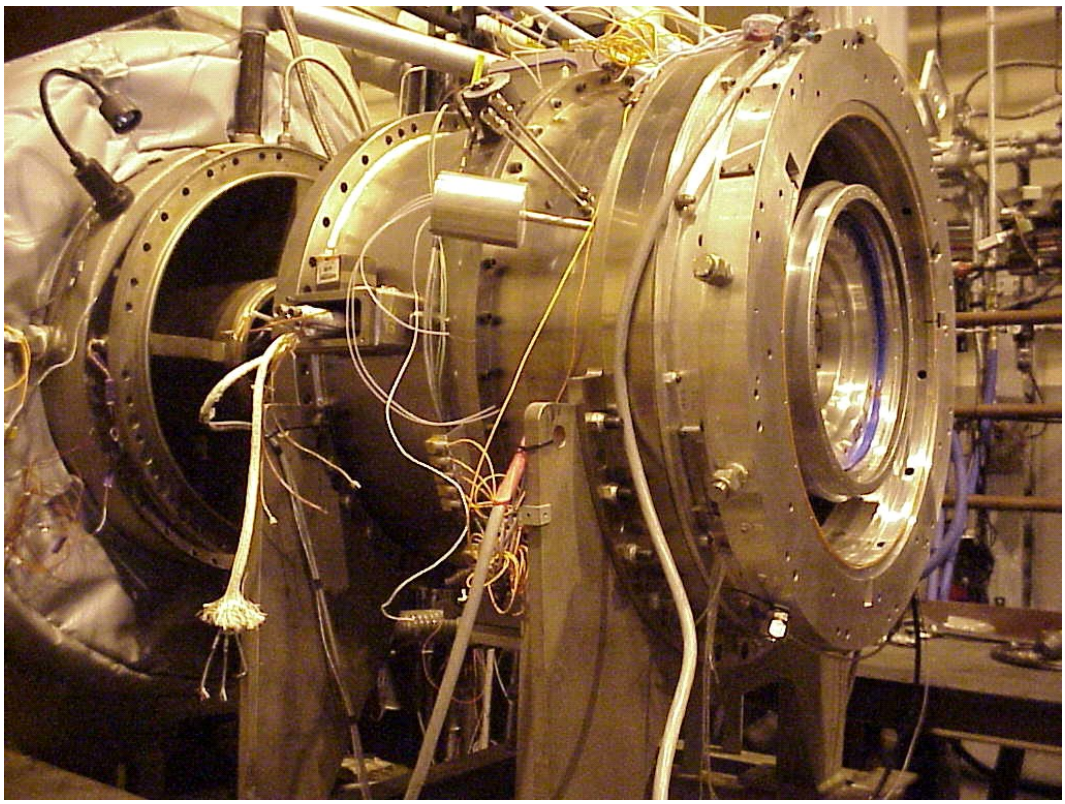
The BAO Kit Team won the Commander's Cup Award (Team) at the recent AFRL Corporate Awards. AFRL/PR members of this team included (pictured, from L to R) Dr. Kirk Yerkes, Mr. Steven Vukson, Capt David Pfahler, Mr. Gary Loeber, Dr. Thomas Reitz, Mr. Cameron Riepenhoff, and Dr. Joseph Fellner. Not pictured are Dr. Russ Spyker and Capt William E. Notbohm.

The Critical Pulsed Detonation Engine Experiment Team won the S&T Achievement Award (Team) at the recent AFRL Corporate Awards. Pictured (from L to R) are Dr. Frederick R. Schauer, Mr. Dale T. Shouse, Dr. James R. Gord, and Mr. Jeffrey S. Stutrud.

Ms. Chanda Smith won the Administrative Excellence Award (Individual) at the recent AFRL Corporate Awards.

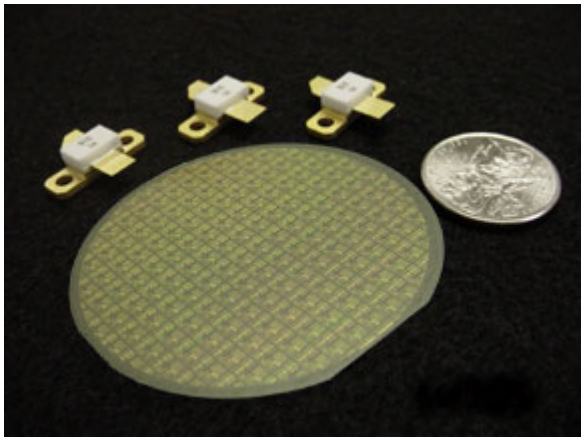
FIRST PHASE OF TRF RESEARCH PROGRAM COMPLETED: Propulsion Directorate engineers recently completed Phase 1 of an inlet profile generator research effort in the Turbine Research Facility (TRF) at Wright-Patterson AFB, Ohio. The generator was designed to replicate the exit conditions from the combustor that impinge on the high pressure turbine stage by splitting the main flow into a series of flows, conditioning them, and then injecting the flow back into the core flow. The first phase of this effort was focused on obtaining basic flow information including pressure profiles and turbulence levels exiting the simulator, as well as mass flow rates, pressures, and temperatures within the generator. Various pressure profiles were generated which more accurately simulate the combustor exit profile with higher total pressures being present along the end walls. High turbulence levels (upwards of 20 percent) consistent with combustors were also measured. Phase 2 of this program will shift the focus to the effects of these profiles on a highly instrumented, high pressure vane which is currently being installed behind the simulator. This phase will include measurements of surface pressure and heat flux at three different spanwise locations. These measurements will allow engineers to obtain an understanding of the impact of various inlet conditions on the vane performance as well as guide designers towards an optimal combustor exit profile. (Dr. M. Polanka, AFRL/PRTT, (937) 255-1922)

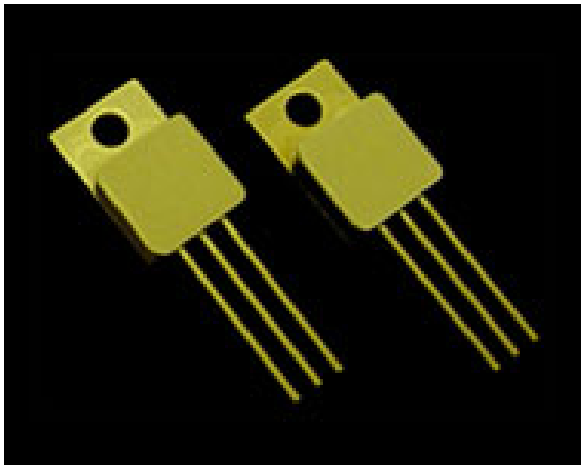




The Propulsion Directorate recently completed Phase 1 of an inlet profile generator research effort in the Turbine Research Facility

SiC POWER DEVICE RELEASED FOR COMMERCIAL SALE: SemiSouth Laboratories, Inc. of Starkville, Mississippi, recently released their power Junction Field Effect Transistor (JFET) switching device for commercial sale. This device, dubbed the Harsh Environment, Low Loss Field Effect Transistor (HEL2FET™), offers component manufacturers a series of 600 V silicon carbide (SiC) switching devices with application to motor drives, converters/inverters, and other electrical power equipment with high temperature operating requirements. The Propulsion Directorate managed the technical effort that culminated in the commercial transition of this SiC power device. The Air Force's More Electric Aircraft has several power system requirements that may be satisfied by this technology. Specifically, electromechanical actuator motor drives, which control flight surfaces, have a high operational temperature requirement that cannot be satisfied using conventional silicon device technology. Other applications include motor drives for fuel pumps, power modules, solid state circuit breakers, radiation tolerant power management and distribution for space platforms, and integrated radar power supplies. In addition, commercial users have placed initial orders for these devices to evaluate them for applications ranging from drill head motors for oil exploration to aerospace platforms. (Dr. J. Scofield, AFRL/PRPE, (937) 255-5949)



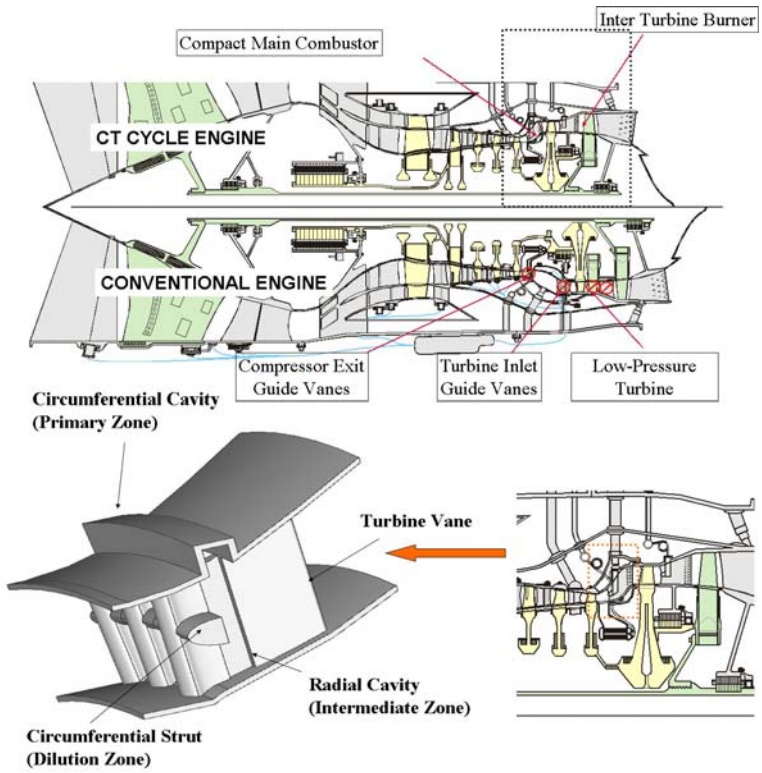


The Harsh Environment, Low Loss Field Effect Transistor (HEL2FET™) was recently released for commercial sale

TESTS DEMONSTRATE FUTURE ENGINE TECHNOLOGY: The Propulsion Directorate is considering a revolutionary gas turbine engine for propulsion applications for future gas turbine engines. This engine uses a near constant temperature (CT) cycle and an Inter-Turbine Burner (ITB) where additional heat is added to the working fluid between the high-pressure turbine (HPT) and low-pressure turbine (LPT) stages to provide large amounts of power extraction from the LPT. This energy can be used to power a large fan for a high bypass ratio transport aircraft, to drive a generator for power generation, power a lift fan, or to power unconventional weapons systems. Conventional gas turbines cannot meet these power demands without a loss of engine thrust, and would ultimately lead to an on-board secondary power source to provide energy for these applications, adding considerable cost and weight to the system. Ultra-Compact Combustor (UCC) technology is essential in the development of the CT cycle engine, since this technology would lead to an overall engine weight and size reduction. High-pressure UCC tests conducted in PR's High Pressure Combustor Research Facility (HPCRF) have demonstrated the feasibility of using this compact system for advanced main combustion and ITB systems. These tests were run at various combustor operating conditions to simulate the advanced gas turbine combustion system

The UCC operating on JP-8 fuel during a typical test

environment. The UCC uses high swirl in a circumferential cavity to enhance reaction rates, which translates to a reduced combustor volume and ultimately a reduction in engine length. The UCC design integrates compressor and turbine features which will enable a shorter and potentially less complex gas turbine engine. Experimental results from the UCC at elevated pressure indicate that the combustion system operates at 95-99 percent combustion efficiency over a wide range of operating conditions burning JP-8+100 fuels. Axial flame lengths are extremely short, at about 50 percent of those of conventional systems. Most impressive is the combustor lean-blowout (LBO) values which are a factor of two lower than conventional systems, enabling the use of the UCC as an ITB where very low temperature rise is needed to achieve optimal work extraction from the LPT. The development of this technology will increase combustion performance and enable the possibility of increased power extraction from the LPT, while reducing the weight and cost of advanced gas turbine propulsion systems. (Dr. J. Zelina, Mr. C. Neuroth, and Mr. D. Shouse, AFRL/PRTC, (937) 255-7487)



Schematic comparing the CT Cycle Engine (incorporating a UCC) to a Conventional Engine

MS. PEARCE DELIVERS KEYNOTE ADDRESS AT UNIVERSITY OF DAYTON BANQUET: The Propulsion Directorate's Ms. Patricia Pearce was the keynote speaker at the University of Dayton's (UD's) "Dinner with an Engineer" held on 14 July 2004. This event is one of the highlights of the university's Women in Engineering (WIE) Summer Camp, a week-long program offering high school girls the opportunity to explore engineering career fields and experience college life. This year marked the 31st WIE Summer Camp, and over the history of this program, thousands of girls from across the nation have participated. The "Dinner with an Engineer" portion of the program gives the participants a chance to meet one-on-one with practicing women engineers. This year, the 74 WIE Summer Camp participants were joined by 44 practicing women engineers for the dinner. Ms. Pearce, a program manager in PR's Aerospace Propulsion Division (AFRL/PRA), discussed opportunities for women in engineering and conveyed her experiences over more than 20 years of service as an engineer for the Air Force. Feedback on her presentation was overwhelmingly positive, and Dr. Joseph E. Saliba, Dean of UD's School of Engineering, commented that Ms. Pearce "…provided them with the knowledge that women engineers can and have made a significant impact in the world of engineering." (Mr. A. Boudreau, AFRL/PRAT, (937) 255-1237)

Ms. Patricia Pearce gave the keynote address at the University of Dayton's "Dinner with an Engineer"

DR. HOFFMAN ELECTED CHAIRMAN OF CARBON SOCIETY: Dr. Wesley Hoffman of the Propulsion Directorate's High Temperature Components Group (AFRL/PRS) was recently elected Chairman of the Executive Committee of the American Carbon Society (ACS). This is the highest elected position in the ACS, and Dr. Hoffman was elected to serve for a 3-year term. The election took place during Carbon2004, an international meeting on carbon hosted by the ACS, which was held from 11-16 July 2004 in Providence, Rhode Island. The

Dr. Wesley Hoffman was recently elected Chairman of the Executive Committee of the American Carbon Society (ACS)

ACS is an international society that is dedicated to the study and application of a very diverse group of carbon materials used in every aspect of society. (Dr. W. Hoffman, AFRL/PRSM, (661) 275-5768)

STUDENT RESEARCHERS ASSIST IN GROWTH OF DIAMOND FILMS: Two student researchers, Messrs. R. Dustin Wehr (Wright Scholar) and G. Tyler Schweinfurth (STEP[§]), have been engaged in a summer research project to enhance the Propulsion Directorate's existing 1.5 kW Diamond reactor. These enhancements are needed to provide the capability to produce diamond films with uniform, well-controlled boron doping. Production of these films will allow R&D of diamond passivation layers engineered with specific resistivities for high power devices. The technique involves bubbling gas through a solution of boric acid and high vapor pressure solvents, and it does not have the respective safety or uniformity and control problems associated with earlier boron doping techniques that utilize either toxic gases (diborane) or exposure of a solid boron source in a plasma. Used in conjunction with the novel nucleation process (NNP), thin, uniform boron doped diamond films can be selectively grown on substrates. The students have produced a matrix of un-doped diamond films as a baseline for the growth parameters. Modifications to the system are nearly complete, and the boron doping experiments will begin shortly. (Dr. S. Heidger, AFRL/PRPE, (937) 255-6932)

WRIGHT SCHOLAR PROGRAM ATTRACTS BEST AND BRIGHTEST: The Wright Scholar Research Assistant Program, initiated by the Propulsion Directorate in 2002, is now well into its third successful year. The Wright Scholar program is a 10-12 week paid internship in which high school juniors and seniors have the opportunity to work hand-in-hand with scientists and engineers across Wright-Patterson AFB. This summer, students are working in a variety of settings within the Air Force Research Laboratory, the Air Force Institute of Technology, and the Aeronautical Systems Center. This program continues to draw the brightest and mostly highly motivated students. Evidence of this is that 11 of the 30 Dayton area students admitted into the program this year recently graduated at the top of their high school class as either a valedictorian or a salutatorian. (Ms. S. Hubbard, AFRL/PROP, (937) 255-3428)

Want more information?

- A more detailed article on the Wright Scholar program was published in the 23 July 2004 edition of the *WPAFB Skywrighter*.[**] This article is available by clicking on the link below: http://www.skywrighter.com/people/2004/0723/12wrightscholars.asp

[§] STEP = Student Temporary Employment Program

[**] Gillmaster, L.L, "Wright Scholars Graduate at the Top of Their Class," *WPAFB Skywrighter*, Vol. 45, No. 29, p. 12A, July 23, 2004

Some of the participants in the 2004 Wright Scholar Program