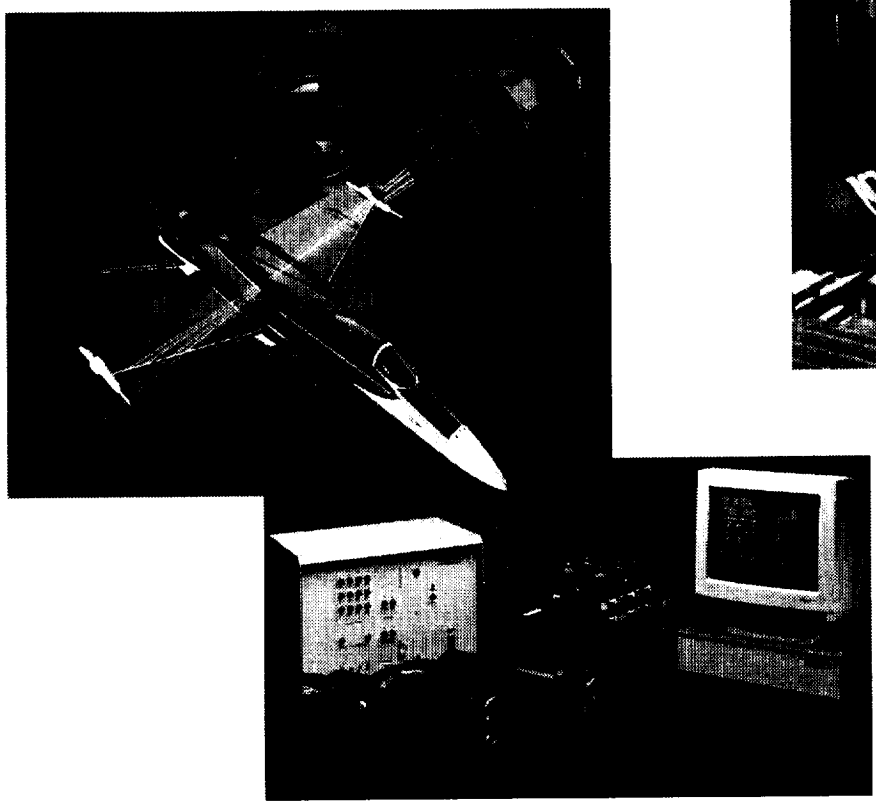
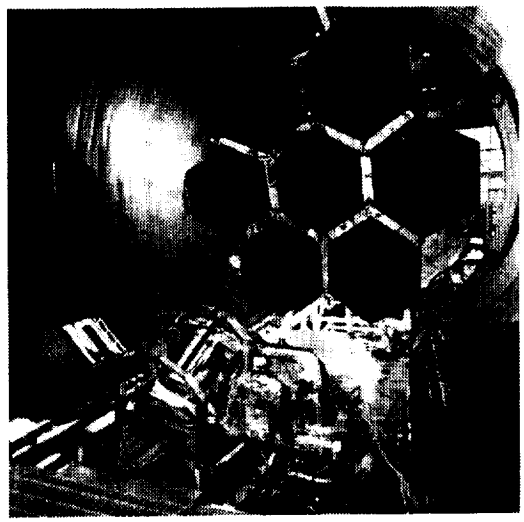
NASA/TM—1999-209649

SBIR Success Stories at NASA Glenn Research Center

Walter S. Kim and Dean W. Bitler
Glenn Research Center, Cleveland, Ohio

George M. Prok, Marie E. Metzger, Cindy L. Dreibelbis,
Meghan R. Howe, and George D. Novak
Omni Corporation, Cleveland, Ohio





December 1999

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National Aeronautics and
Space Administration

Glenn Research Center

December 1999

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SBIR Success Stories at NASA Glenn Research Center

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National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio 44135

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Abstract

This booklet of success stories summarizes the NASA Glenn Research Center's accomplishments and successes by the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. These success stories are the results of selecting projects that best support NASA missions and also have commercialization potential. Each success story describes the innovation accomplished, commercialization of the technology, and further applications and usages. The company name and the NASA contact person are identified to encourage further interest and communication to occur.

Introduction

Congress legislated the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs to ensure that the best innovative concepts become part of federal research and development efforts that benefit the nation. This has resulted in NASA receiving high quality research from small businesses to meet specific mission needs as well as directly contributing to the nation's economy and industry. Successful innovations have enabled small businesses to grow, mature, and provide jobs for the nation by moving ideas from the drawing board to the marketplace.

In 1982, Congress legislated the SBIR program under the Small Business Innovation Development Act. The objectives established by law are: to stimulate technological innovation in the private sector, to strengthen the role of small businesses in meeting federal research and development needs, to increase the commercial application of the research results, and to encourage participation of socially and economically disadvantaged businesses.

The legislation re-enacted in 1992 extended and strengthened the SBIR program and increased the emphasis on pursuing commercial applications of SBIR results.

NASA, under the policy directive of the Small Business Administration, allocates 2.5 percent of its extramural research and development budget to the SBIR program. The funding is to be used for research or research and development during the first two phases of the three-phase process. The SBIR program phases and the implementation of the program are described on the web site: http://www.grc.nasa.gov/WWW/TU/sbir/sbir.htm.

With the resounding success of the SBIR program, in 1992, Congress legislated the Small Business Research and Development Enhancement Act, which created the Small Business Technology Transfer (STTR) program. The NASA STTR program is designed to convert the nations' investment in research carried out by research institutions into new commercial technologies for advancing economic competitiveness and high-tech development. NASA allocates 0.15 percent of the extramural research and development budget to the STTR program. Like SBIR, the funding is to be used for the first two phases of the three-phase process. The STTR program is described on the web site: http://www.grc.nasa.gov/WWW/TU/sbir/sttr.htm.

The NASA Office of Aerospace Technology provides overall policy direction for the SBIR and STTR programs, with the Program Management Office hosted at the Goddard Space Flight Center. The NASA Field Centers identify the technical needs, evaluate proposals, make recommendations for selections, and manage individual projects. All NASA Field Centers and the NASA Strategic Enterprises work together to meet the agency's strategic goals and missions.

NASA Glenn Research Center (GRC) devotes a large effort to ensure that each proposal receives a fair and competent evaluation. The recommendation for award selection is based on the highest innovation that meets GRC's mission goals and at the same time have the best commercialization potential.

The commercialization of innovation is emphasized even before technical topics are drafted. Throughout the feasibility determination in Phase I and the research and development in Phase II, the commercialization potential is evaluated as an important criterion for award selection. At the completion of the research or research and development, the program/project offices and technical staff are highly encouraged to enter into Phase m activities to utilize and commercialize the innovation. The small business is also expected to use non-Federal capital to pursue private sector applications. A comprehensive handbook with guidelines and procedures for initiating Phase m is available at: http://ehb2.gsfc.nasa.gov/sbir/fcpm.html.

The success stories were compiled to document and identify the innovative accomplishments and commercial activities, primarily from the Phase II projects that have been completed for several years. These success stories are the results of the collaboration by the small businesses and the Contract Officer's Technical Representatives (COTR) who managed the contracts. Each success story has been approved for public release by a signed release from a company official. All the success stories are posted on the Internet at: http://sbir.gsfc.nasa.gov/SBIRJsuccesses/contents.htm.

The purpose of this booklet of success stories is to identify the successes achieved by the GRC's COTRs and the small businesses. This booklet should encourage further usage and applications of the SBIR developed technologies and also promote further commercialization of these SBIR products.

SUBSONIC SYSTEMS

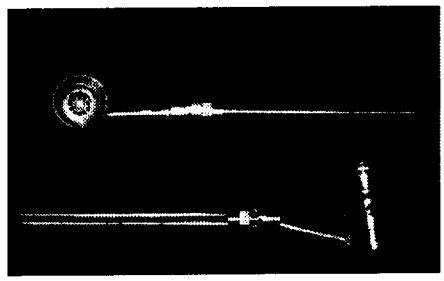
Small Business Innovation Research

Dual-Spray Fuel Nozzle for Low Emissions Gas Turbine Combustors

CFD Research Corporation
Huntsville, AL

INNOVATION

A fuel nozzle that provides high turndown fuel-air ratio and low emissions in small aircraft gas turbine engines



Prototype Fuel Nozzle

ACCOMPLISHMENTS

- Designed fuel nozzle using advanced CFD analysis
- Tested prototype nozzles at atmospheric pressure for lean blowout
- Fabricated and tested selected fuel nozzle in full annular combustor test at idle and simulated full power operating conditions
- Demonstrated lean blowout fuel-air ratio of 0.003 at idle conditions. This exceeds the current AST goal of 0.005

COMMERCIALIZATION

- Received over $175K in contracts from industry to study potential in AST combustors
- Selected as candidate by GE for 70% NOx reduction regional engine combustor program; fabrication and testing started in 1998. Received $500K in Phase III funding from GE
- If successfully demonstrated, nozzle has potential of being a production engine part. CFDRC will give the rights of the fuel nozzle to a fuel nozzle vendor in exchange for royalty fees

GOVERNMENT/SCIENCE APPLICATIONS

- Potential use in low emission aircraft gas turbine combustors
- Basis for further development of low NOx fuel-air mixers for land based gas turbine engines and other industrial combustion systems, e.g., burners, boilers, process heaters, etc.

Glenn Research Center
Advanced Subsonic Technology
3-004

1998 Phase II, NAS3-26616 rev 9/99
NASA Contact - Chi-Ming Lee
Company Contact - Cliff Smith

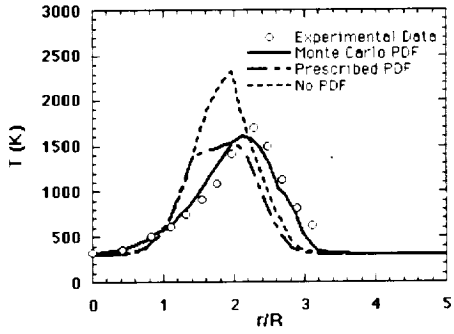
Small Business Innovation Research

A Probability Density Function (PDF) Method for Turbulent Reacting Flow

CFD Research Corporation
Huntsville, AL

INNOVATION

A Monte Carlo simulation technique for turbulent combustion and its viability for practical applications



Monte Carlo PDF Solution Agrees with Experimental Data (Piloted Jet Diffusion Flame) much Better than Solutions Using Simpler Models

ACCOMPLISHMENTS

- A Monte Carlo solution module for the composition PDF was developed to solve finite-rate chemical kinetics in turbulent flows
- The PDF module was coupled with a general purpose CFD code, CFD-ACE
- The PDF module was validated against experimental data for hydrogen and hydrocarbon combustion

COMMERCIALIZATION

- The PDF solution module has been incorporated into CFD-ACE and is being used by BMW and other selected clients on a trial basis
- The PDF solution module is also usable as an enhancement for other finite-volume CFD codes, such as CFD-FASTRAN
- The PDF solution technique is being improved and extended with additional NASA and CFDRC funding

GOVERNMENT/SCIENCE APPLICATIONS

- Prediction of emissions in turbulent combustion, especially automotive and aircraft engines and stationary power sources

Lewis Research Center
Advanced Subsonic Technology
3-003

1998 Phase II, NAS3-26608 3/98
NASA Contact - Karl Owen
Company Contact - Dr. Andy Leonard

Small Business Innovation Research

Unstructured Density Based CFD Methodology for Gas Turbine Combustor Applications

CFD Research Corporation
Huntsville, Alabama

INNOVATION

A new methodology for efficient generation of large high-quality tetrahedral and prismatic meshes for CFD gas turbine combustor and other applications

ACCOMPLISHMENTS

Developed software package CFD-GEOM with:

- Automatic curvature based unstructured grid generation on trimmed-NURBS geometry models
- Interactive assignment of boundary and volume conditions, directly on the geometry, configurable for various flow solvers
- Tetrahedral grid mesher for large grids (100K-300K cells per minute) based on Delauney and Advancing Front techniques
- Prismatic grid mesher for resolution of boundary layers based on Advancing Layers Method
- Direct interface to commercial CAD systems

COMMERCIALIZATION

- CFD-GEOM is being marketed as a stand-alone product for structured and unstructured grids, as well as in conjunction with CFDRC flow solvers
- Installed at more than 250 organizations worldwide for a variety of CFD grid applications. The average license fee is ~$5K

CFD-GEOM, with a direct link to UniGraphics, accepts true CAD data without IGES translation and generates complete unstructured grid systems with minimal user input

GOVERNMENT/SCIENCE APPLICATIONS

- Standard grid generation software for the National Combustor Code (NCC) computational framework
- Several Phase III extensions by NASA and CFDRC with NASA contributing $375K

Lewis Research Center
Advanced Subsonics Technology
3-006

1993 Phase II, NAS3-27632, 3/98
NASA Contact - Nan-Suey Liu
Company Contact - Dr. Vincent Harrand

MATERIALS

Small Business Innovation Research

Durable Interface Coatings for Ceramic Matrix Composites

Advanced Ceramics Corp. (ACC)
Lakewood, OH

INNOVATION

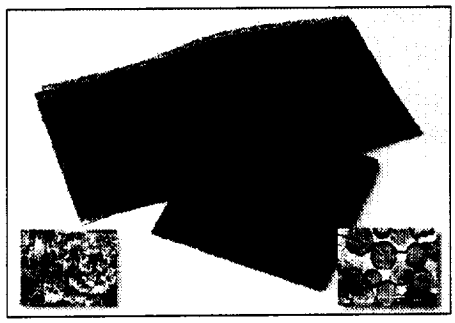
An interface coating that protects fiber-reinforced ceramic composites from moisture and oxidation at high temperatures

ACCOMPLISHMENTS

- Developed a family of high temperature and doped boron nitride coatings that offer orders of magnitude improvement in interface durability for SiC/SiC composites
- Demonstrated that fibers in woven fabrics can be coated as uniformly as fibers in tows

COMMERCIALIZATION

- Firm supplies durable interface coatings on fiber tows from a new scaled-up facility
- Sales of $100K to Fiber Reinforced Ceramic Matrix Composites (FRCMC) developers in 1996, with 1997 sales estimated at $300K
- Three new jobs were created



Digitized Images of Composites and Cloth

GOVERNMENT/SCIENCE APPLICATIONS

- Major impact on the Enabling Propulsion Materials Program of High Speed Research showed that the new interface coatings are more than 1,000 times more durable than the state-of-the-art
- Applicable to national programs aimed at ceramic composites development for military and terrestrial application
- Durability of interface coatings has been proven in glass, SiC, and Blackglas™ matrices

Lewis Research Center
Materials

1993 Phase II NAS3-27690, SS-174 6/97
NASA Contacts - Serene Farmer

Small Business Innovation Research

A Software Tool to Design Thermal Barrier Coatings

Deformation Control Technology, Inc.
Cleveland, OH

INNOVATION

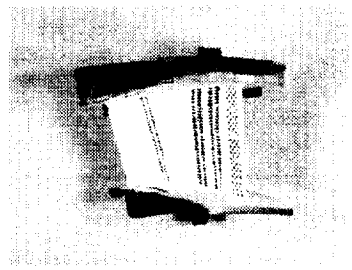
Software that enables design of ceramic coatings to enhance coating life and coated component life

ACCOMPLISHMENTS

- Successful incorporation of 5 main stress drivers into Thermal Barrier Coating (TBC) model, including oxidation
- First fundamental description of the role of oxidation in TBC failure
- Provided first basic statistical descriptors for quantifying interactive material property effects
- Provided basis for NASA TBC design innovation, patent pending

COMMERCIALIZATION

- In use to analyze test results and design TBCs for electric power generation turbine applications
- Commercial contract in excess of $10K was initiated prior to completion of Phase II work
- Strong commercial interest in future analysis based on the success of an exploratory contract
- This SBIR project resulted in an increase in employment, from 2 to 3 employees



Coated Aircraft Gas Turbine Stator Vane

GOVERNMENT/SCIENCE APPLICATIONS

- Presently in use to define failure mechanisms in TBCs
- Continued use to reduce costly experimentation while developing new TBC concepts
- In support of NASA HITEMP and Hybrid-Hyperspeed programs

Lewis Research Center
Materials
3-002

1993 Phase II NAS3-27539 3/98
NASA Contact - Bill Brindley
Company Contact - B. Lynn Ferguson CD-98-77105

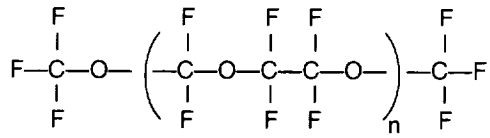
Small Business Innovation Research

Perfluoropolyether Lubricating Fluids

Exfluor Research Corp.
Austin, TX

INNOVATION

New perfluoropolyether fluids for use at higher temperature (260°C) and in an oxygen environment, at lower costs than previous alternatives



Structure for perfluoropolyether

ACCOMPLISHMENTS

- Development of a series of fluids with good low temperature (-40°C) and high temperature (260°C) properties as well as oxygen stability

COMMERCIALIZATION

- Company has leveraged this technical knowledge to expand into specialty fluorocarbon chemical production for uses other than lubrication
- Technology licensed to the 3M Company
- Received $750K Air Force contract for optimizing a chemical structure for use in high performance jet engines
- Firm employment doubled as a result of SBIR activities

GOVERNMENT/SCIENCE APPLICATIONS

- Useful in the electronic industry and in Space Shuttle and high performance aircraft where lubricants are required that have a wide liquid range and a low volatility
- Technology can increase the operating temperature of jet engines, thus increasing engine efficiency

Lewis Research Center
Materials

1984 Phase 2, NAS3-24856, SS-114; 8/29/96
NASA Contact - William R. Jones

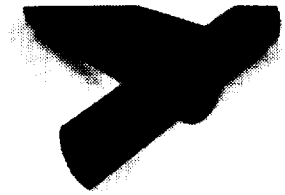
Small Business Innovation Research

Non-Toxic, Resin Transfer Molding (RTM) Processable, High Temperature Matrix Resin

Foster-Miller, Inc.
Waltham, MA

INNOVATION

RTM processable, high temperature (T_g>600°F), low toxicity matrix resin system



Composite Cylinders Manufactured via new RTM

ACCOMPLISHMENTS

- Developed matrix resin system by combining reactive diluents with the NASA developed AMB-21 polyimide resin
- Lowered the viscosity of the base resin significantly, decreased the amount of volatile by-products during cure, and increased cured T_g of AMB-21
- Successfully fabricated demonstration composite cylinders by RTM

COMMERCIALIZATION

- Estimated market for RTM processable PMR-15 substitute is $20-40 M/year
- Formed Pyrogonn I.I.c. for commercialization of this and related technologies
- Sample materials provided to McDonnell-Douglas, Dow-UT NASA, and GE Engines, for testing and evaluation

GOVERNMENT/SCIENCE APPLICATIONS

- This resin system could replace PMR-15 as a high temperature organic matrix for carbon reinforced composites in aerospace propulsion systems and other high temperature structural applications where cost effective fabrication to near net-shape via RTM is desirable

Lewis Research Center
Materials
3-029

1994 Phase I NAS3- 27532, 12/98
1996 Phase II NAS3- 27618
NASA Contact - Mike Meador
Company Contact - Joseph Boyce

Small Business Innovation Research

Fiber Optic Systems for Composite Process Monitoring and Control

GEO-CENTERS, INC.
Newton Center, MA

INNOVATION

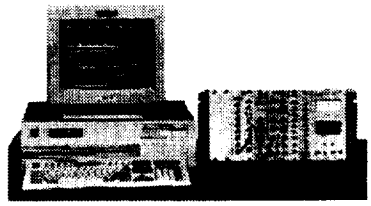
Fiber optic sensors for monitoring polymer matrix cure state, temperature, and pressure

ACCOMPLISHMENTS

- Developed fiber optic sensors for up to 400° C
- Developed methods to imbed fiber optic sensors into polymer matrix composites
- Methods of entrance and egress of optical fibers from autoclaves and molds to instrumentation were developed
- A simple instrument capable of monitoring 16 fiber optic sensors was developed

COMMERCIALIZATION

- Received commercial, DOE, and DOD funding totaling $250K (Phase III). DOE work was on resin transfer molded composites and DOD work was on monitoring the cure of molded explosives
- As a result of this SBIR, GEO-CENTERS further enhanced their business by purchasing a technical competitor, Micromet, Inc.
- Two new jobs were created



Polymer Matrix Cure Monitoring & Process Control System

GOVERNMENT/SCIENCE APPLICATIONS

- Important to NASA's Aeronautics High Temperature Materials (HITEMP), High Speed Civil Transport (HSCT), and Enabling Propulsion Materials (EPM) Programs
- Important to all military advance propulsion engine programs

Lewis Research Center
Instrumentation & Controls

1987 Phase II, NAS3-25817, SS-168, 9/97
NASA Contact - Kenneth Bowles

Small Business Innovation Research

Processing of Metal Matrix Composites with Controlled Microstructures

Materials & Electrochemical Research (MER) Corporation
Tucson, AZ

INNOVATION

A semi-continuous hallow cathode magnetron system for coating small diameter fiber within multifilament fiber tow followed by matrix coating

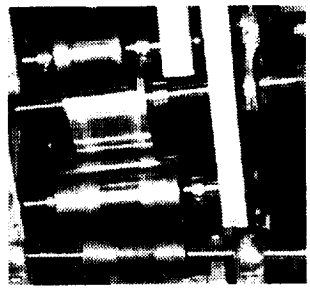
ACCOMPLISHMENTS

- Developed fiber-spreading equipment
- Developed segmented hallow cathode magnetron coating system
- Developed interfacial coating for ceramic (Al_2O_3, SiC) and carbon fibers
- Developed matrix coating (copper, superalloys)
- Developed consolidation techniques, and characterized composite mechanical and thermal properties

COMMERCIALIZATION

- Produced variety of metal-coated fibers to various customers for evaluation
- Sales and internal development of more than $575K
- Prepared and presented business plan to several strategic alliances and venture capital groups to raise $5.5M for electronic heat sink applications

Glenn Research Center
Materials
3-025



MER Automated Fiber Spreader

GOVERNMENT/SCIENCE APPLICATIONS

- High temperature composite materials for aerospace applications
- For use as a heat sink spreader for electronics
- For general use in heat management applications

1993 Phase II, NAS3-27543, 5/99
NASA Contact - Susan Draper
Company Contact - Dr. R. O. Loutfy

Small Business Innovation Research

NEKTON: Tool for Coating Process Simulations

Nektonics, Inc.
Cambridge, MA

INNOVATION

Powerful simulation software for the modeling and analysis of a wide range of coating flows

Slide coating Analysis with NEKTON

ACCOMPLISHMENTS

- Produced a fluid dynamics computer modeling tool for simulation and analysis of a wide range of coating flows

COMMERCIALIZATION

- Commercial version brought to market by Fluent, Inc. as NEKTON 2
- Product introduced computational fluid dynamics to the coatings industry
- Developed annual revenue of $400K
- Superseded in 1996 by NEKTON 3.0 for industrial customers
- NEKTON 2 continues to be used in universities

GOVERNMENT/SCIENCE APPLICATIONS

- Software was used in the Surface Tension Driven Convection Experiment (STDCE), a low gravity fluid physics experiment flown on STS-50, June 1992 and STS-73, October 1995
- NEKTON can be used to model coatings in such diverse industries as paper, magnetic media, film and adhesives

Lewis Research Center
Materials

1990 Phase 2; NAS3-26725, SS-132; 5/12/97
NASA Contact - Bruce Rosenthal

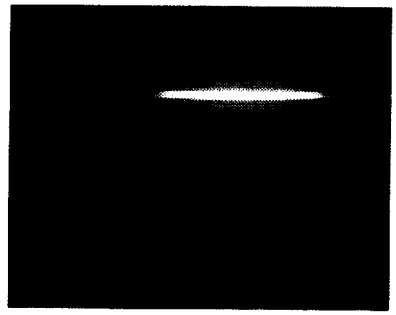
Small Business Innovation Research

Innovative Laser Furnace

Penn Laboratories, Inc.
Dahlonega, GA

INNOVATION

A high temperature laser furnace for mechanical testing of ceramic fibers



Laser Fiber Test Sample

ACCOMPLISHMENTS

- Furnace incorporates room temperature mounting grips and a uniform hot zone with relatively sharp boundaries and controllable length
- Furnace capable of selective heating of single crystal fibers at temperatures of up to 3000°C
- Capable of implementing tensile tests under thermal load conditions

COMMERCIALIZATION

- Firm received a Phase III contract for $163K from Metal Samples Co., Inc.

GOVERNMENT/SCIENCE APPLICATIONS

- Being applied to NASA's Advanced High Temperature Materials Program (HITEMP), in Enabling Propulsion Materials (EPM) Program, and part of the High Speed Research Program (HSR)
- Useful to Navy programs such as High Temperature Phase Diagram studies
- Furnace used at NASA Lewis Research Center for ceramic fiber research

Lewis Research Center
Materials

1990 Phase 2, NAS3-26663, SS-133, 3/21/97
NASA Contact - Ali Sayer

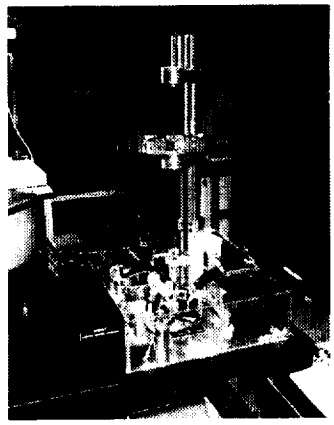
Small Business Innovation Research

Laser Float-Zone Process Improvements

Penn Laboratories, Inc.
Dahlonega, GA

INNOVATION

Laser heated Melt Modulation™ technique for ceramic fiber growth



Laser Heated Fiber Growth Furnace

ACCOMPLISHMENTS

- A furnace was designed and constructed to evaluate laser heated ceramic fiber growth
- Multi-Wave™ pyrometer was developed for use in this furnace
- Pyrometer measures temperatures up to 3000°C in an area as small as 75 microns, at a distance of 30 mm from the target, with field of view approximately 2,000 microns

COMMERCIALIZATION

- The Multi-Wave™ pyrometer, Multi-Wave™ HT-1C, is currently commercially available
- NASA Lewis purchased two Multi-Wave™ pyrometers for fiber research at a total cost of $30K

GOVERNMENT/SCIENCE APPLICATIONS

- Technology applied in NASA's High Temperature Engine Material Program(HITEMP)
- USAF Office of Scientific Research is applying the technology at the Wright Laboratory Materials Directorate in the Edge-Defined Film-fed Growth (EFG) project

Lewis Research Center
Materials

1988 Phase 2, NAS3-25944, SS-159, 3/24/97
NASA Contact - Al Sayer

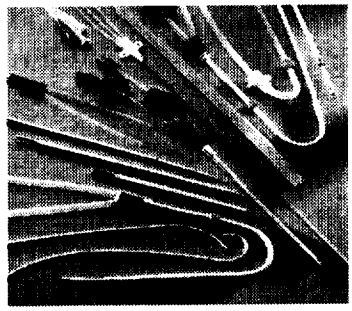
Small Business Innovation Research

Oxidation Resistant Ti-6Al-4V-SiC Composite Materials by Ion-Beam Processing

Spire Corporation
Bedford, MA

INNOVATION

Developed silver-based antimicrobial coatings for reducing bacterial adhesion and proliferation on medical devices.



96C578A

Antimicrobial IBAD silver coated medical device components

ACCOMPLISHMENTS

- Demonstrated significant reduction in bacterial growth and colonization on treated medical device surfaces

COMMERCIALIZATION

- Foundations of the antimicrobial coating technology were developed under NIH and NSF grants and contracts. Continued work with NIH includes development of silver-based antimicrobial coatings for additional medical device applications.
- Earlier, the NASA SBIR Phase I contract contributed to the establishment of Spire's ion beam assisted deposition (IBAD) processing capabilities, upon which the antimicrobial coating technology is based
- Spire currently processes over ten thousand medical device components annually, resulting in several hundred thousand dollars in annual revenues
- Broad medical device applications, i.e. various catheters and other implantable medical devices, are being pursued with significant growth expected over the next few years
- Increase in employment of 4 people

GOVERNMENT/SCIENCE APPLICATIONS

- Potential uses in limiting device-related infection for military applications/personnel
- St. Jude Medical is currently using the Antimicrobial Coatings on prosthetic mechanical heart valve suture rings

Lewis Research Center
Materials
3-011

1987 Phase I, NAS3-25326, 6/98
NASA Contact - James Smialek
Company Contact - Ron Scharlack

Small Business Innovation Research

Perfluoropolyalkylether Fluid as High Temperature Lubricant

Ultrasystems, Inc.
Irvine, CA

INNOVATION

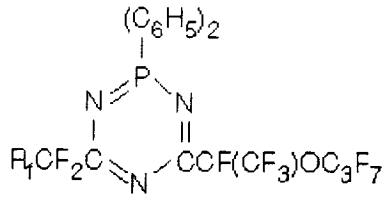
Perfluoropolyalkylether fluids for lubrication capable of performance between -50 and 316°C in the presence of metals in oxidizing environments

ACCOMPLISHMENTS

- End-capping perfluoropolyalkylether chains with phospha-s-triazine rings has produced fluid stability up to 316°C
- The new fluid also reduces degradation in the presence of metals or under boundary lubrication and resists metal corrosion
- Evaluated a series of perfluoropolyalkylether fluids and greases and developed performance guidelines

COMMERCIALIZATION

- Phase II report is used nationwide as guidance data for lubricating greases and fluids, with company researchers recognized as technology leaders
- Commercial applications include aircraft instrument bearing lubricant, computer memory disc surface lubricant, vacuum pump oils and base stock for specialty greases and antiseize compounds
- Ultrasystems was absorbed by Lubricating Specialties Co., Technology Products Division
- Received two Air Force contracts - one contract is worth $600K



Structure for Perfluoropolyalkylether (Phospha-triazine capped)

GOVERNMENT/SCIENCE APPLICATIONS

- NASA applications include potential replacement of fluids currently used in space instrumentation as well as advanced aircraft lubrication
- Used in satellite guidance systems including Geostationery Operational Environmental Satellites (GOES); Television Infrared Observation Satellite (TIROS); Earth Radiation Budget Satellite (ERBE); LANDSAT series

Lewis Research Center
Materials

1983 Phase II, NAS3-24632, SS-115, 7/96
NASA Contact - William R. Jones

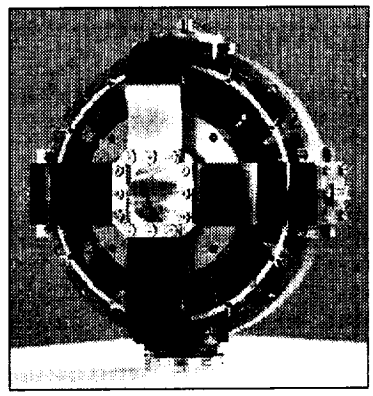
POWER AND ON-BOARD PROPULSION

Small Business Innovation Research

Alternator and Suspension for Free Piston Stirling Engines

Clever Fellows Innovation Consortium, Inc.
Troy, NY

INNOVATION
A compact alternator/motor with reduced size and mass and high efficiency that has unlimited service life



High-efficiency affordable reciprocating motor

ACCOMPLISHMENTS

- Produced a commercial prototype solar power generator using STAR™ alternator/motor
- Constructed and demonstrated a working model for a cryogenic cooler with STAR™ alternator/motor
- Demonstrated the STAR™ alternator/motor for uses as a motor in a gas or air compressor

COMMERCIALIZATION

- Licensed Cummins to build and market a solar powered generator, this project recently sold to Kombassan, a Turkish firm
- STAR™ alternator/motor units sold around the world, $900K in sales in 1995
- Contract with New York state for $395K to develop gas fired generator
- Sold multiple licenses for cryogenic refrigeration services utilizing STAR™ based cryogenic coolers

GOVERNMENT/SCIENCE APPLICATIONS

- Solar dynamic power for future use in Space Station
- STAR™ motor could be used on cryogenic coolers in test programs throughout NASA
- Combined with Thermoacoustic engine to produce ultra-reliable generator for micro co-generation products

Lewis Research Center
Space Power Technology

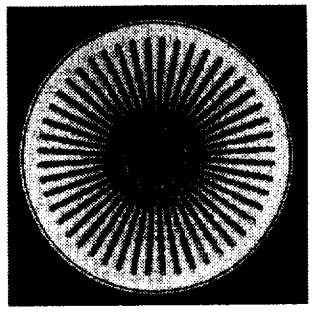
1990 Phase 2, NAS3-26603, SS-44; 8/97
NASA Contact - Lanny Thieme

Small Business Innovation Research

High Temperature, Silicon Carbide, Power Thyristor

Cree Research, Inc.
Durham, NC

INNOVATION
A process for producing high performance power Thyristors in Silicon Carbide (SiC) capable of operating at 350°C



Micrograph of a 10 Amp 4H-SiC Power Thyristor

ACCOMPLISHMENTS

- Demonstrated the first power thyristor in SiC
- Fabricated high-performance Thyristors in SiC that passed 1000 hour test at 350°C
- Operated SiC thyristors to temperatures as high as 500°C
- Achieved world record SiC power level of 4.2 kilowatts

COMMERCIALIZATION

- Increased SiC material and device sales by >$3.8M
- Created 14 new jobs and saved existing jobs
- Initiated tremendous worldwide interest in the area of SiC power semiconductors, resulting in multi-$M programs in SiC MOSFETs for government and commercial labs
- Total market potential for SiC Power Thyristors would be >$200M

GOVERNMENT/SCIENCE APPLICATIONS

- Will be used in military electric vehicles, i.e., electric tanks, more-electric airplane, and shipboard power distribution
- Applicable for high temperature power conditioning in spacecraft and will reduce weight and size of spacecraft
- Can be used to replace Silicon power devices in power circuits for large electric vehicles and locomotives, and for solid state power distribution of electricity for utilities
- SiC Thyristors offer much lower switching losses than silicon devices in theses applications. Potential power savings of >$1B/yr are possible

Lewis Research Center
Space Power
3-022

1991 Phase II, NAS3-26927, 9/98
NASA Contact - Gene Schwarze
Company Contact - John Palmour

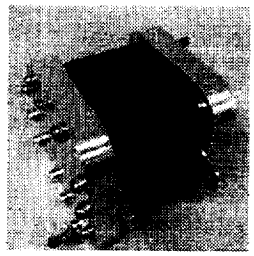
Small Business Innovation Research

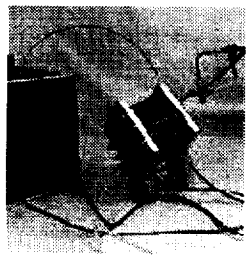
High Efficiency Proton Exchange Membrane Fuel Cell

ElectroChem, Inc.
Woburn, MA

INNOVATION

Self humidified, high reactant utilization fuel cell stack for operation with H_2/O_2 reactants





PEM Fuel Cell

ACCOMPLISHMENTS

- Development of an "off-the-shelf" commercial fuel cell as part of ElectroChem's product line of research supplies and instruments to the fuel cell community
- ElectroChem, Inc. has made advancements in their design of fuel cell stacks. As a result, they will be able to manufacture larger fuel cell stacks (500 cm^2) which will deliver up to 2kW of power in addition to their smaller fuel cell stacks (50 cm^2)
- The ElectroChem, Inc. Proton Exchange Membrane (PEM) fuel cell can operate at high reactant utilization, does not need external reactant humidification, and can operate at atmospheric pressure

COMMERCIALIZATION

- System integration work proceeding for other applications such as back-up power systems, recreational vehicles, and stand-alone regenerative power systems
- Can be used in rural electrification and in underwater vehicles

GOVERNMENT/SCIENCE APPLICATIONS

- Study of fuel cell operation in upper atmospheric scientific balloon for NASA Wallops' Balloon Program
- Could be used in remote power applications for the defense industry
- Commercial sales of $53K for several units to NASA for use in atmospheric studies as part of a SBIR Phase III

Lewis Research Center
Space Power Technology

1992 Phase II, NAS3-27242, SS-180, 11/97
NASA Contact - Dr. Patricia Loyselle

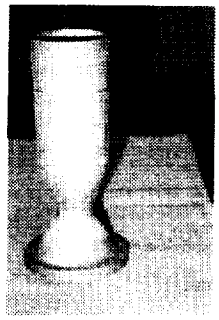
Small Business Innovation Research

High Temperature Oxidation-Barrier Coatings for Refractory Metals

Electroformed Nickel, Inc.
Huntsville, AL

INNOVATION

Electrodeposited iridium as a high density coating to prevent oxidation of the refractory substrate and insure long life in severe thermal environments



Iridium plated 100Lb Rhenium Thrust Chamber

ACCOMPLISHMENTS

- Using the iridium coating over rhenium substrates prototype radiation cooled attitude control thrust engines, such as would be employed in satellites for maneuvering, accumulated hot firing cycle life to 14 hours at 3400°F, has been demonstrated by NASA Lewis Research Center

COMMERCIALIZATION

- Sales to date have totaled $107K
- A strategic alliance has been formed between Rhenium Alloys Inc. (to supply rhenium chambers by an improved powder metallurgy process), Electroformed Nickel, Inc. (to provide a high integrity iridium oxidation barrier coating) and TRW (to design, qualify and market the product)
- A full time engineer has been added to the professional staff to manage the new coating process
- TRW anticipates a widespread use of this process in a product aimed at world-wide commercial satellite customers

GOVERNMENT/SCIENCE APPLICATIONS

- USAF Phillips Laboratories has show an interest in this coating process for rocket nozzle inserts to extend the life and range of missile devices. Such an insert was fabricated and successfully fired by Edwards AFB
- Interest in these coatings has also been expressed by Lawrence Livermore National Laboratories

Lewis Research Center
Space Power
3-018

1989 Phase II, NAS3-26256, 9/98
NASA Contact - Robert Jankovsky
Company Contact - Glen Malone

Small Business Innovation Research

Composite Regenerator for Stirling Engine

Energy Science Labs, Inc.
San Diego, CA

INNOVATION

A process for carbon fiber flocking on a carbon substrate to produce high radial and low axial thermal conductivity at high temperatures (1000°C)

ACCOMPLISHMENTS

- Development of a carbon-carbon composite matrix Stirling engine regenerator providing high temperature capability and high radial, low axial conduction
- Developed a carbon fiber flocking process to fabricate the composite matrix regenerator

COMMERCIALIZATION

- Sales of $1.8M in 1995, half of the sales were generated by carbon fiber flocking
- Expansion of manufacturing facility by over 40% and increase in staffing by 33%
- High conductance thermal interface gaskets for use in aerospace thermal management and electronics packaging
- Transverse reinforcements for delamination resistance in composite materials used in primary aircraft structures

Example of Flocked Carbon Fiber

GOVERNMENT/SCIENCE APPLICATIONS

- Compliant heat transfer interface and composite phase change material for advanced refrigerators/freezers for Space Station and Space Shuttle
- Black surfaces for stray light suppression in spacecraft instruments

Lewis Research Center
Materials

1989 Phase 2, NAS3-26249, SS-41 4/2/96
NASA Contact - Diane Chapman

Small Business Innovation Research

Fresnel Lens Photovoltaic Concentrator Array

ENTECH, Inc.
Keller, TX

INNOVATION

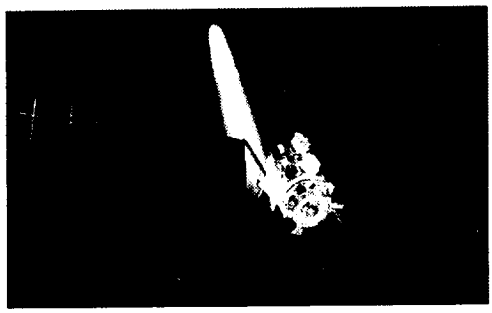
Domed/Arched refractive concentrator system providing higher efficiency at lower weight and cost

ACCOMPLISHMENTS

- Developed both Point-Focus Mini-Dome lens and Line-Focus Cylindrical Lens Arrays for space power application
- SCARLET array (derived from line-focus lens concept) provides spacecraft power at one-half to one-third the cost of current arrays

COMMERCIALIZATION

- Over $1 Million in Space Lens sales to date to Boeing, AEC-Able Engineering, and others.
- More than 20 new jobs were created at these companies
- Approximately $10 Million in space array sales to date by ENTECH's customers
- SCARLET arrays now being commercialized/marketed by AEC-Able Engineering Team
- $350K in Phase III funding from NASA Lewis



SCARLET Space Array

GOVERNMENT/SCIENCE APPLICATIONS

- NASA/USAF/Boeing PASP+ (Photovoltaic Array Space Power plus Diagnostics) experiment flown in 1994 - first successful demonstration of ENTECH lens concept in space
- BMDO/NASA Lewis SCARLET 1 Array successfully built and space qualified for METEOR satellite
- 2,600 watt SCARLET 2 array to provide power for JPL's New Millennium Deep Space One Mission launch in 1998

Lewis Research Center
Space Power Technology

1985 Phase II: NAS3-25192, 12/97
NASA Contact - Michael Piszczor

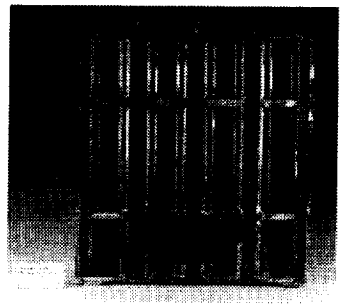
Small Business Innovation Research

Lightweight Graphite/Aluminum (Gr/Al) Space Radiators for Thermal Management

Foster-Miller, Inc.
Waltham, MA

INNOVATION

Lightweight metal matrix composites (MMCs) with superior heat removal for structural radiators and thermal management of electronics



Radiator Panel from MMC

ACCOMPLISHMENTS

- Designed and produced Gr/Al radiator panel with built-in heat-pipe housing
- Demonstrated substantial weight and thermal performance over baseline radiator components. Electronic substrate provided 10% reduction in weight and 50% improvement in performance. Radiators provide a 50% improvement in weight and/or performance
- Designed, produced and demonstrated substantial benefits in terms of heat removal and weight for Gr/Al as a substrate for electronics

COMMERCIALIZATION

- Commercial sales for MMC substrates for electronics will be over $40K for 1997
- Two new jobs were created
- Army funded a program for $550K to place inserts in MMC components

GOVERNMENT/SCIENCE APPLICATIONS

- Gr/Al MMCs have application in dimensionally stable spacecraft structure and optical platforms, and they have thermal management application in gas turbines and rocket engines.
- Use of these MMCs as a substrate in electronic products will reduce cost and improve reliability of radars, satellites, and other electronics intensive systems
- Samples of MMC electronics substrates are being supplied to government prime contractors for evaluation. Keen interest has also been expressed by aerospace contractors in MMC radiators.

Lewis Research Center
Space Power Technology

1992 Phase II, NAS3-27385, 11/97
NASA Contact - Karl Baker

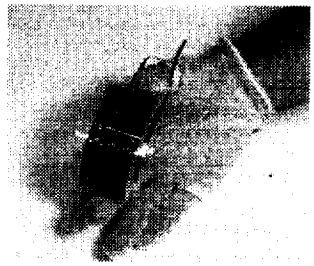
Small Business Innovation Research

Light-Weight Flexible Thin Film Solar Cells for Space Applications

International Solar Electric Technology
Inglewood, CA

INNOVATION

Light-weight, high power density thin film solar cells on flexible substrates



Flexible Copper-Indium-Diselenide Solar Cells

ACCOMPLISHMENTS

- Produced polycrystalline copper-indium-diselenide (CIS) solar cells on flexible metal foils
- Work led to an Air Force-supported project that resulted in the demonstration for the first time of CIS solar cells with over 1 kW/kg power density on polymeric substrates
- Received innovation award from NASA

COMMERCIALIZATION

- A joint experimental effort is in progress with a multinational company to produce the cells on a specific light weight substrate
- Received over $3M Advanced Technology Program contract for communications applications of these devices

GOVERNMENT/SCIENCE APPLICATIONS

- Very attractive for many NASA, commercial and military satellite power applications
- Useful for terrestrial applications where light weight and flexibility of solar cell is desired

Lewis Research Center
Space Power
3-027

1990 Phase II, NAS3-26615, 12/98
NASA Contact - Henry Curtis
Company Contact - Bulent Basol

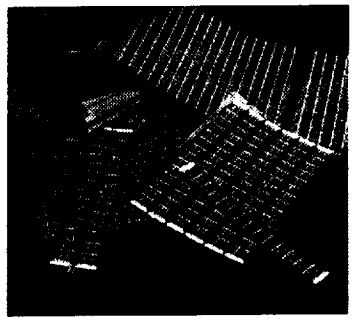
Small Business Innovation Research

Flexible, Lightweight, Amorphous, Silicon Solar Cells Tuned for Air Mass Zero (AMO) Spectrum

Iowa Thin Film Technologies, Inc.
Ames, IA

INNOVATION

Tandem amorphous silicon modules on a polyimide substrate



Flexible Amorphous Silicon Modules on a Polyimide Substrate

ACCOMPLISHMENTS

- Optical modeling to calculate thicknesses of device layers for maximum AMO solar spectrum absorption
- Deposition parameters for device layers optimized for performance of amorphous silicon solar cells in space
- Construction of a dedicated tandem amorphous silicon deposition machine

COMMERCIALIZATION

- Company sales as a result of SBIR were $200K and growing
- ITFT increased from a few employees to 12 full time and 8 part time employees
- Phase III monies totaled $4.7M from several government and private sources. The DOE National Renewable Energy Labs (NREL) is the largest government contract.
- Private investment provided the financing of a just completed production facility

GOVERNMENT/SCIENCE APPLICATIONS

- ITFT amorphous silicon modules for space applications are under evaluation at the NASA JPL
- ITFT modules are under evaluation at the NREL/DOE Laboratory for terrestrial applications
- Companies evaluating our material for space applications include Lockheed-Martin and TRW, which includes testing in space

Lewis Research Center
Space Power Technology

1999 Phase II, NAS3-26244, 10/97
NASA Contact - Dennis Flood

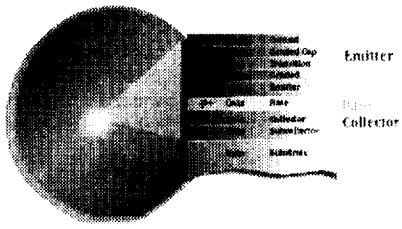
Small Business Innovation Research

High Volume Metal Organic Chemical Vapor Deposition (MOCVD) Device Wafer Production

Kopin Corporation
Taunton, MA

INNOVATION

Advanced heterostructure devices for microwave communications



Epitaxial Layer Structure

ACCOMPLISHMENTS

- Introduced the first carbon-doped Heterojunction Bipolar Transistor (HBT) Device Wafer to commercial market
- Introduced InGaP HBT Device Wafer for High Reliability Applications

COMMERCIALIZATION

- Leading provider of HBT Device Wafers in world wide markets
- Commercial sales increased 6x, from ~$3M in 1995 to est. $18M in 1998
- HBT L-Band Power Amplifiers (PA) Rapidly Penetrating Cellular Handset

GOVERNMENT/SCIENCE APPLICATIONS

- HBT Circuits used as high power X-band radar applications
- HBT will migrate to higher frequency microwave communication applications

Lewis Research Center
Energy Conversion/Communication
3-017

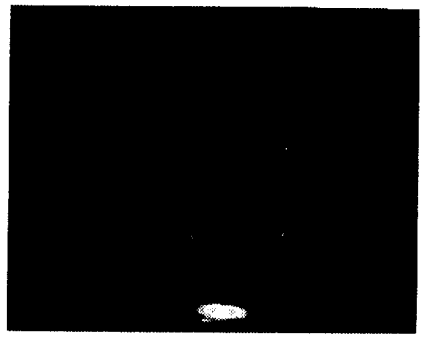
1988 Phase I, NAS3-25449, 9/98
1988 Phase II, NAS3-25948
NASA Contact - Dennis Flood
Company Contact - Dr. Noren Pan

Small Business Innovation Research

Arc Reduction Procedures for Solar Cells

Physical Sciences, Inc.
Andover, MA

INNOVATION
Solar cell construction procedure that reduces frequency of arcing in high voltage solar cells



High Voltage Arcing

ACCOMPLISHMENTS

- Developed construction method for solar cells to reduce high voltage solar cell arcing
- Developed UHV test facility and methods for evaluating the mechanism of arcing in high voltage solar cells in Low Earth Orbit (LEO)
- Successfully tested reduced arc frequency solar cells during shuttle mission

COMMERCIALIZATION

- Established testing service for alternate solar cell designs
- Sales of more than $100K for testing service

GOVERNMENT/SCIENCE APPLICATIONS

- NASA purchased test panels for $15K which were tested successfully on Space Shuttle STS-62.
- Very useful to Space Station
- Applicable to any LEO power system

Lewis Research Center
Space Power Technology

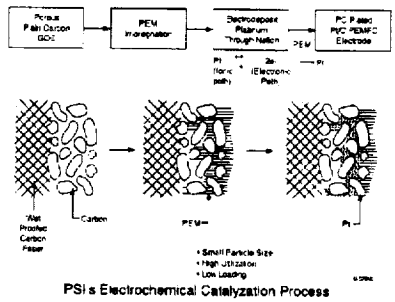
1987 Phase II, NAS3-25797, SS-175, 9/97
NASA Contact - David Snyder

Small Business Innovation Research

Electrocatalysts for High Efficiency Solid Polymer Electrolyte Fuel Cell

Physical Sciences, Inc.
Andover, MA

INNOVATION
Electrochemical catalyzation (ECC) technique for producing high performance proton-exchange membrane electrodes



PSI s Electrochemical Catalyzation Process

PSI's Electrochemical Catalyzation Process

ACCOMPLISHMENTS

- Improved ECC process
- Application to high surface area, high utilization, high catalyst loading electrodes demonstrated
- Specific activity improvement demonstrated

COMMERCIALIZATION

- The improved process is being qualified for commercial fuel cells by manufacturers that include International Fuel Cells and Energy Partners
- Phase III funding of $190K obtained from the Department of Energy and the State of Florida
- ECC Technology can be used to develop and manufacture lower cost, higher performance Polymer-Electrolyte membrane (PEM) fuel cells

GOVERNMENT/SCIENCE APPLICATIONS

- Applications include long term Lunar and Mars missions, underwater autonomous vehicle propulsion, and terrestrial remote, and portable power

Lewis Research Center
Space Power Technology

1990 Phase II, NAS3-26699, SS-191, 9/97
NASA Contact - Dr. Richard Baldwin

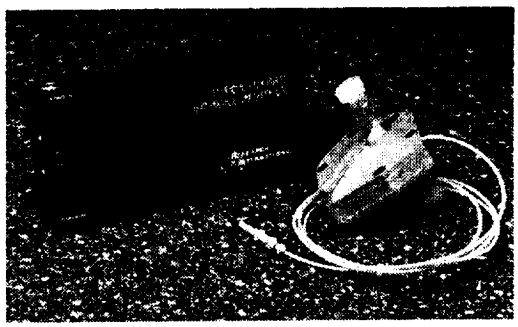
Small Business Innovation Research

Solid State Micromachined Pump

Research International
Woodinville, WA

INNOVATION

Micromachined pump with no moving parts



Micromachined pump

ACCOMPLISHMENTS

- Pumping technology incorporated into a four-channel solid-state fluorometer
- A patent is pending for this product, Analyte 2000, a portable, automated immunoassay system for the detection of toxins and pollutants
- This final product combines technology from another SBIR award from Johnson Space Center

COMMERCIALIZATION

- Commercial applications include detection of toxins and pollutants in coal mines, as well as an early warning smoke detector for industrial applications
- Company tripled in size from 10 to 30 employees with the hiring of 16 new engineers and scientists at a total cost of $2.44 M

GOVERNMENT/SCIENCE APPLICATIONS

- Micromachined pump used for cooling electronics in space
- Circulation of heat transfer fluids on spacecraft
- Monitor for fire hazards and hazardous gas releases within shipboard magazines on naval warships

Lewis Research Center
Johnson Space Center
Space Power Technology

1990 Phase II: NAS3-26610; SS-131; 3/20/97
1992 Phase I - JSC
NASA Contact - Karl Baker

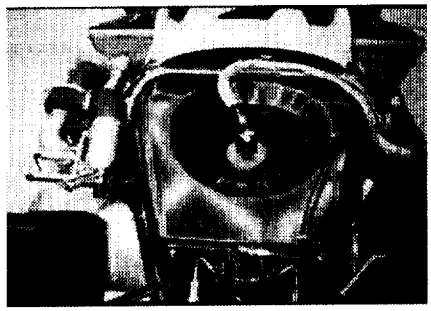
Small Business Innovation Research

Carbon Fiber Flywheel for Power Generation and Attitude Control

SatCon Technology Corp.
Cambridge, MA

INNOVATION

A 2 Kw/hr carbon fiber flywheel capable of power over a speed range of 20,000-40,000 rpm



SatCon Flywheel Energy Storage System

ACCOMPLISHMENTS

- The round trip efficiency of the energy storage wheel, including power conditioning electronics, is expected to exceed 85%
- The flywheel is supported on magnetic bearings which reduce the parasite losses of the system

COMMERCIALIZATION

- Technology is directly applicable to the flywheel energy storage program SatCon currently has with Chrysler's Patriot project, a high performance hybrid electric race vehicle, that uses flywheel storage to improve the efficiency by load-leveling a turbine-alternator
- Pursuing customers such as public utilities for use as a load leveling intermediate energy storage device, and for uninterruptible power supplies

GOVERNMENT/SCIENCE APPLICATIONS

- Flywheel is aimed toward a combined energy storage and attitude control system which can be used on ISSA as well as all types of NASA, commercial, and military spacecraft ranging from low power communication or observing spacecraft to orbital platforms
- SatCon is committed to developing flywheel products for automotive, industrial, utility and aerospace applications

Marshall Space Flight Center
Lewis Research Center
Space Power Technology

1989 Phase I ; 1990 Phase II: SS-67; 8/21/96
NASA Contact - Ray Beach

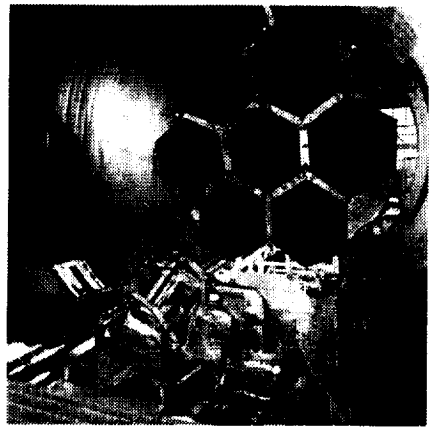
Small Business Innovation Research

Improved Mirror Facet

Solar Kinetics
Dallas, TX

INNOVATION

A spin coating process for depositing aluminum on an all metal honeycomb structure to produce high precision mirrors



Solar Dynamic Ground Demonstration Unit

ACCOMPLISHMENTS

- Demonstrated high precision mirrors can be produced by depositing aluminum on a metallic honeycomb by a spin coating process
- Further improvements were validated in a 2 kW test
- Developed an ultra-lightweight scaled parabolic mirror facet with a specific weight of 1.8kg/m2 with a reflectivity greater than 85%

COMMERCIALIZATION

- Sale of $1 M to Harris Corporation to build panels for use on Space Station
- Terrestrial applications include solar concentrators for solar powered waste detoxifiers
- Created three new jobs

GOVERNMENT/SCIENCE APPLICATIONS

- Government uses include; Space Station, advanced space telescopes and lightweight antenna dishes
- Very efficient, high quality concentrator is important to NASA's Solar Dynamics Program for both space and terrestrial applications

Lewis Research Center
Space Power Technology

1987 Phase II, NAS3-25632, SS-26, 4/17/97
NASA Contact - James E. Calogeras

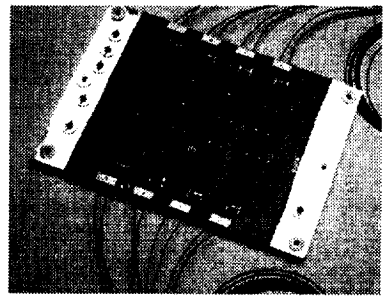
Small Business Innovation Research

High Efficiency, Radiation-Resistant Indium Phosphide Solar Cells

Spire Corporation
Bedford, MA

INNOVATION

Space solar cells having superior radiation resistance for missions in high radiation environments



Indium phosphide Solar Cells

ACCOMPLISHMENTS

- Achieved world record conversion efficiency (>19%) for indium phosphide (InP) cells
- Confirmed radiation hardness by actual flight experiment Photovoltaic Array Space Power Plus Diagnostic (PASP-Plus)
- Basis for current proposal to NASA for a reduced-cost concentrator array

COMMERCIALIZATION

- Led to successful NASA and Navy-sponsored cell development programs using 90% less expensive silicon substrates

GOVERNMENT/SCIENCE APPLICATIONS

- Long-life, reliable photovoltaic power for commercial, military, and NASA satellites in medium-to-high radiation environments (e.g., MEO, GEO, or high LEO)

Lewis Research Center
Space Power Technology

1994 Phase II, NAS3-24857, 12/97
NASA Contact - Dennis Flood

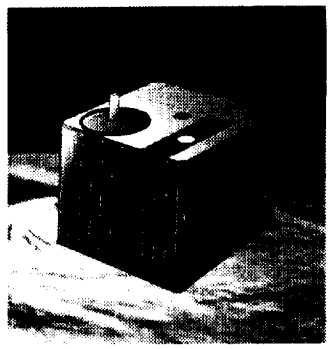
Small
Business
Innovation
Research

Indium Phosphide Solar Cells on Silicon Substrates

Spire Corporation
Bedford, MA

INNOVATION

Lightweight, reduced-cost solar cells for high radiation environment space flight missions.



Satellite with Indium Phosphide on Silicon Substrate Solar Cells

ACCOMPLISHMENTS

- Achieved significant reductions in cell weight (~50%) and substrate cost (>90%)
- NASA program led to additional Navy-sponsored advanced development
- Follow-on program achieved record high conversion efficiency (~13%)

COMMERCIALIZATION

- Flight panel currently under construction for a high radiation mission Space Technology Research Vehicle (STRV 1-C/D) being funded by a $370K Navy contract

GOVERNMENT/SCIENCE APPLICATIONS

- Affordable photovoltaic power for long duration missions in medium-to-high radiation orbits.
- Technology currently being evaluated by at least three solar cell suppliers and users

Lewis Research Center
Space Power Technology

1987 Phase II: NAS3-25798, 12/97
NASA Contact - Dennis Flood

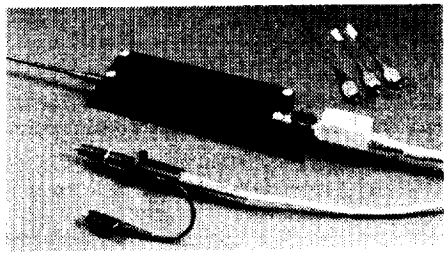
Small
Business
Innovation
Research

Integrated Optical Voltage Measurement System

Srico, Inc.
Columbus, OH

INNOVATION

Voltage sensor probe that allows isolation from electromagnetic interference by converting the electrical signal to an optical signal



Voltage Sensor Probe

ACCOMPLISHMENTS

- Integrated optic high voltage probe with optical signal transmission, eliminates the need for high voltage leads from source to readout
- Optical isolation reduces the safety problems associated with high voltage
- The problem of electrical noise and electromagnetic interference was eliminated as well as problems associated with vibration
- Improved measurement accuracy

COMMERCIALIZATION

- Large scale production of an inexpensive robust probe will be initiated
- Over $1M in sales expected the first few years of production
- Electrical distribution companies will use this system in their power distribution facilities

GOVERNMENT/SCIENCE APPLICATIONS

- Well suited to NASA's stringent requirements for automatic control of aeronautic or space power management and distribution systems
- Kennedy Space Center - for lightning and thunderstorm detection
- Space station power system
- Electromagnetic compatibility testing
- Physiological monitoring of astronauts

Lewis Research Center
Space Power Technology

1993 Phase II, NAS3-27273, SS-45, 9/98
NASA Contact - Richard Patterson

Small Business Innovation Research

Measuring Reversing Flow Pressure Drop in Stirling Engine Heat Exchangers

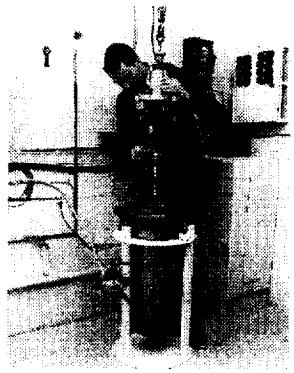
Sunpower, Inc.
Athens, OH

INNOVATION

A unique flexible rig for measuring pressure drop in oscillating flows

ACCOMPLISHMENTS

- Developed an oscillating flow test rig to measure pressure variations in complex engine flows
- Provided insights into flow effects in Stirling engine heat exchanger
- Provided much improved understanding of one of the primary losses in Stirling cycle machines



Oscillating Flow Test Rig

COMMERCIALIZATION

- Improved performance of both Stirling-cycle engines and Stirling-cycle coolers; hence this SBIR has resulted in the continued support from private industry
- Resulted in another SBIR and a University grant that allowed rig modification to also measure oscillating flow heat transfer in regenerators
- Information derived from measurements was incorporated into Stirling computer codes that are being used to design Stirling engines and coolers by private companies

GOVERNMENT/SCIENCE APPLICATIONS

- Stirling engines are a leading candidate for dynamic space power systems - Stirling has been chosen as a backup for the Advanced Radioisotope Power System (ARPS) being developed for deep-space missions
- Stirling engines are applicable for use in terrestrial dynamic power, including remote power generation and cogeneration

Lewis Research Center
Space Power Technology

1984 Phase II, NAS3-24879, 12/97
NASA Contacts - Roy Tew and Lanny Thieme

Small Business Innovation Research

Regenerative Solid Oxide Fuel Cell Technology Development

Technology Management, Inc.
Cleveland, OH

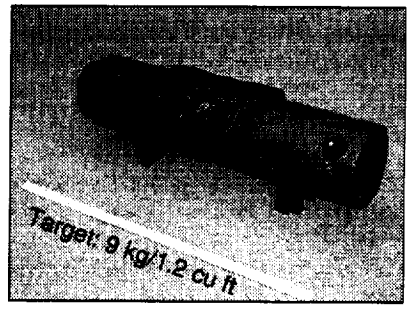
INNOVATION

Solid oxide fuel cell (SOFC) and electrolysis that is combined into a high-efficiency energy storage system

Sulfur-tolerant integrated SOFC/reformer technology that can operate using common hydrocarbon fuels including logistic fuels and biogas

ACCOMPLISHMENTS

- Improved system operation and efficiency
- Scalable fuel cell component technologies
- Integrated systems packaging
- Developed for small, low weight and volume applications



DARPA 500 Watt Portable Power System Mock-up

COMMERCIALIZATION

- Continued support from both commercial (EPRI, GRI, other) and government (DARPA, Navy, NASA, USDA, DOE) contracts to serve multiple portable and stationary applications operating multiple fuels including military logistic fuels and biogas

GOVERNMENT/SCIENCE APPLICATIONS

- Ultra-small, low maintenance, stationary electric power generation applications (down to 100 Watts) operating on multiple sulfur-bearing fuels
- Military (logistic fuel) portable and mobile applications
- Low earth orbit (LEO) and other satellite power applications
- Water electrolysis for the production of hydrogen

Glenn Research Center
Energy Conversion
3-032

1993 Phase II, NAS3-27546, 2/99
NASA Contact - Mark Hoberecht
Company Contact - Benson P. Lee

Small
Business
Innovation
Research

Lightweight Structural Foams from Ceramic Materials

Ultramet

Pacoima, California

INNOVATION

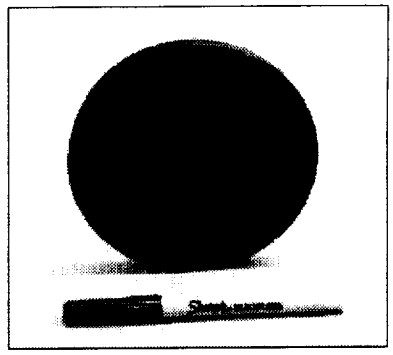
Very lightweight ceramic foams as substrates for reflectors used in space-based solar power systems

ACCOMPLISHMENTS

- Developed technology to produce lightweight open-cell structural foams from ceramic materials such as boron carbide, silicon carbide, and hafnium carbide
- Produced lightweight, high quality reflectors using silicon carbide-hafnium carbide foam substrates with aluminum-coated quartz mirror faceplates
- Ultimately spun off foam technology into medical field, as Hedrocel™ synthetic bone material

COMMERCIALIZATION

- Licensed medical foam technology to Implex (Allendale, NJ), a manufacturer of musculoskeletal implants. Implex has invested $10 million in production facilities and experimental trials. Implex 1996 sales were nearly $1.5 million, with 1998 sales projected at $20-30 million
- Formed joint venture, Cytomatrix (Cambridge, MA), to develop biological cell growth medium using foam technology
- To date, 6 jobs at Ultramet, 30 jobs at Implex, and 4 jobs at Cytomatrix have been created



Lightweight Mirror Structure with Aluminum-Coated Quartz Mirror Faceplate

GOVERNMENT/SCIENCE APPLICATIONS

- Primary NASA application is in solar concentrators for advanced solar dynamic power systems
- Can also be used in solar collectors for ground-based solar power systems

Lewis Research Center
Materials

1986 Phase II, NAS3-25418, SS-177, 8/97
NASA Contact - Jim Calogeras

INSTRUMENTATION AND CONTROLS

Small Business Innovation Research

High Temperature Combustion Diagnostic Method Utilizing Rayleigh Scattering

Aerodyne Research, Inc.
Billerica, MA

INNOVATION

A Dual-Line Detection Rayleigh scattering technique using a copper vapor laser for non-intrusive temperature measurements in combustor flows

ACCOMPLISHMENTS

- Developed a Dual-Line Detection Rayleigh scattering technique to allow subtraction of surface scattering background noise from Rayleigh scattering signals
- Designed and tested an instrument using this Rayleigh scattering technique for non-intrusive measurement of combustor exhaust gas temperatures

COMMERCIALIZATION

- Provides a non-intrusive tool for dynamic time resolved measurement of gas turbulence and temperature
- Technique could be used in research for density measurement and mole fraction of gases
- Research test data is available to industry

Rayleigh Scattering Probe

GOVERNMENT/SCIENCE APPLICATIONS

- System was delivered to NASA Lewis Research Center where it was successfully used on a research combustor
- The technique and research results were passed-on to Polytechnic Universtiy and Air Force Wright Laboratories for use in temperature and turbulence studies of gas flows and for further development of the technique

Lewis Research Center
Instrumentation & Controls

1983 Phase II, NAS3-24613, SS-179, 9/97
NASA Contact - Richard Seasholtz

Small Business Innovation Research

Optimization of Silicon Carbide Production

Aerodyne Research, Inc.
Billerica, MA

INNOVATION

Combining gas phase calculations with experimental observations of surface reactions into a predictive model to optimize chemical vapor deposition (CVD) of silicon carbide

ACCOMPLISHMENTS

- Developed a computer code to model epitaxial Beta-SiC growth in a chemical vapor deposition process
- A 2-D predictive model of Beta-SiC growth in a chemical vapor disposition reactor was delivered to NASA Lewis
- Co-authored a paper with Lewis comparing model with experimental results from Lewis

COMMERCIALIZATION

- Code was used in development of a methane arcjet for space propulsion
- Received $25K in development funding from the Navy and $35K in commercial sales
- Computer models have application for improved high temperature electronic devices
- Work done under this SBIR project is still cited by researchers involved in SiC CVD modeling
- Received a related SBIR from Air Force Office of Scientific Research (AFOSR)

Heated Susceptor in CVD Facility

GOVERNMENT/SCIENCE APPLICATIONS

- The code was used by NASA Lewis to optimize production of single crystal semiconductors for high temperature electronic devices
- Results from this SBIR are still used by researchers involved in SiC CVD modeling
- Silicon carbide is an important electronic material for advanced aerospace applications that involve high temperature, high power and high frequency

Lewis Research Center
Instrumentation and Controls
3-001

1984 Phase II, NAS3-23891, SS-190, 12/97
NASA Contact - Malia Kuczmarski
Company Contact - Laurie Dean CD-98-77040

Small Business Innovation Research

Turbomachinery Flowfield Temperature Measurement Linear Imaging Diagnostics

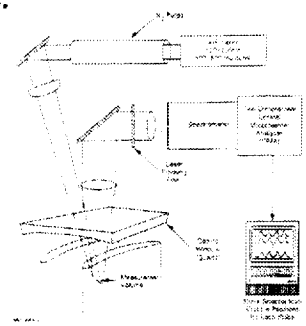
Aerodyne Research, Inc.
Billerica, MA

INNOVATION

Non-intrusive measurement of gas temperature and/or density for use in turbomachinery

ACCOMPLISHMENTS

- Demonstrated the feasibility of non-intrusive measurement of temperature and density in a flowing gas stream
- Developed an optical measurement technique for use in compressor flow fields



Linear Imaging Temperature Measurement System Design

COMMERCIALIZATION

- $11K Phase III funding for further development of the temperature measurement system at Glenn's compressor test facility
- A new approach for non-intrusive measurement of gas temperature based on an O_2-LIF technique has been demonstrated at GRC as a result of the Phase III funding
- GRC may use additional Phase III funds for demonstration tests in a compressor after reviewing results in the final report

GOVERNMENT/SCIENCE APPLICATIONS

- This technique will be used in the "Smart Green Engine" Program
- Will be used in the NASA Physics and Process Modeling Program (PPM)
- Useful in turbomachinery research over a temperature range of 300K-500K
- Useful in research applications requiring non-intrusive measurement of gas temperature

Glenn Research Center
Instrumentation
3-034

1991 Phase II, NAS3-27000, 6-99
NASA Contact - Mark P. Wernet
Company Contact - Kurt D. Annen

Small Business Innovation Research

Microscopic and Macroscopic Modeling of Layer Growth Kinetics and Morphology in Vapor Deposition Processing

CFD Research Corporation
Huntsville, Alabama

INNOVATION

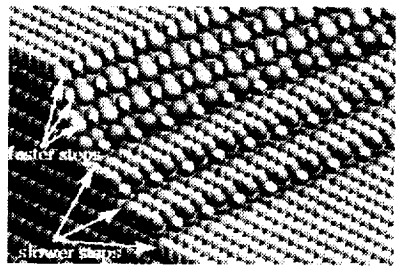
Simulation tool (CFD-FILM) to enable development of new materials for semiconductor and opto-electronic applications, as well as for structural and thermal barrier coatings

ACCOMPLISHMENTS

- Developed a Monte Carlo microscopic model to simulate specific morphological characteristics of film growth such as step bunching, thermal roughening, polytype growth, growth uniformity, defect formation, etc.
- Created a commercial software, CFD-FILM, to analyze morphology of growing films
- Validated the microscopic model against experimental data for materials such as Si, diamond and SiC
- Coupled CFD-FILM with a general purpose macroscopic transport/chemistry software, CFD-ACE

COMMERCIALIZATION

- Contributed to increased sales of CFD-ACE to leading semi-conductor equipment vendors and process designers (~$500K/year)
- CFD-FILM is marketable as a stand-alone module, as well as an add-on module with CFD-ACE
- Application projects from industry and research projects from government agencies



Simulation of Step Bunching in SiC Growth (using CFD-FILM)

GOVERNMENT/SCIENCE APPLICATIONS

- Provides an enabling technology for advanced materials such as GaN, GaAs, InP, and SiC
- Provides a base technology for extension to plasma-substrate interactions in low pressure etch processes

Lewis Research Center
Instrumentation & Controls
3-005

1992 Phase II, NAS3-27287, SS-, 2/6/98
NASA Contact - Amon Chait or Maria Kuczmarski
Company Contact - Dr. Ananthia Krishnan

Small Business Innovation Research

Blackbody High Temperature Optical Sensor

Conax Buffalo Technologies L.L.C.
Buffalo, NY

INNOVATION

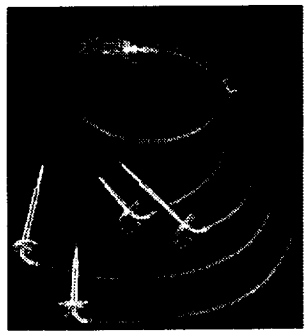
An optical sensor system for gas pass temperatures utilizing a thermally emissive insert imbedded in a sapphire lightguide

ACCOMPLISHMENTS

- Sensing element has a time constant less than one second, a diameter of 0.06 inches and has been tested at temperatures up to 1500°C
- Calibrated sensor under static conditions against thermocouples, accuracy is estimated to be +18° C

COMMERCIALIZATION

- Complete optical sensor systems have been fabricated for commercial use
- Large scale production of optical sensor systems for commercial and government use is in progress
- A Phase III effort of qualifying this optical sensor system for use commercially was financed by Electric Power Research Institute (EPRI), GE Aircraft Engines IR&D, and NASA
- More than $500K was received for optical sensor qualification and other commercial sales



Military Aircraft Fiber Optic Exhaust Gas Temperature Sensor System

GOVERNMENT/SCIENCE APPLICATIONS

- Hardware was developed for the NASA Fiber Optic Control Systems Integration (FOCSI) Program
- Development programs are ongoing for use of this system in military aircraft and ground based power generation turbines

Lewis Research Center
Instrumentation & Controls

1986 Phase I, NAS3-25451, SS-156, 3/24/97
NASA Contact - Robert Baumbick

Small Business Innovation Research

High Temperature, Silicon Carbide, Power MOSFET

Cree Research, Inc.
Durham, NC

INNOVATION

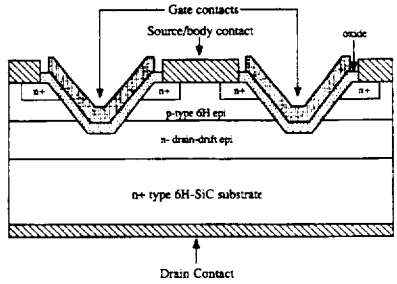
A process for producing high performance power metal/oxide semiconductor field-effect transistors (MOSFETs) in Silicon Carbide (SiC)

ACCOMPLISHMENTS

- Demonstrated the first vertical power MOSFET in SiC
- Fabricated a high-performance MOSFETs in SiC that can operate up to 300°C
- Received Patent on this technology

COMMERCIALIZATION

- Increased SiC material and device sales by >$3M
- Created 12 new jobs and saved existing jobs
- Initiated tremendous worldwide interest in the area of SiC power semiconductors, resulting in multi-$M programs in SiC MOSFETs for government and commercial labs
- Total market potential for SiC Power MOSFETs would be >$2B



Cross-Section of a SiC Power MOSFET

GOVERNMENT/SCIENCE APPLICATIONS

- Will be used in aircraft engines
- Applicable for high temperature electronics in space craft and will reduce weight and size of spacecraft
- Can be used to replace Silicon power devices in power circuits for electric motors and power control, for electric vehicles, robotics, and power supplies
- SiC MOSFETs offer much higher efficiencies than silicon in these applications. Potential power savings of >$1B/yr are possible

Lewis Research Center
Instrumentation and Controls
3-021

1988 Phase II, NAS3-25956, 9/98
NASA Contact - Lawrence Matus
Company Contact - John Palmour

COMMUNICATIONS

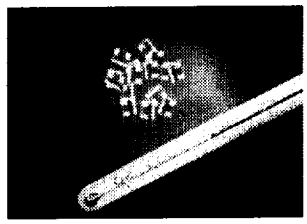
Small Business Innovation Research

Passive Temperature Compensating Attenuator

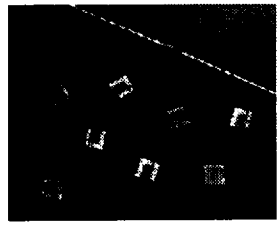
EMC Technology, Inc.
Cherry Hill, NJ

INNOVATION

A family of passive high frequency temperature compensation attenuators (Thermopad ®)



Thermopad ®



Smartload ®

ACCOMPLISHMENTS

- A 25% improvement in temperature compensation
- The development of high Temperature Coefficient of Resistance (TCR) thick film materials
- High frequency attenuator designs
- Automated high frequency measurement development
- Power Sensing Termination (SmartLoad ®) development

COMMERCIALIZATION

- ~ $1 Million in commercial sales in 1997
- 10 new jobs at EMC Technology, Inc.

GOVERNMENT/SCIENCE APPLICATIONS

- Components are currently flying on four different military and commercial satellite programs including:
  - IRIDIUM, Motorola telecommunications satellite
  - VMISAT, European meteorological satellite
  - INTELSAT, Global Star telecommunications satellite
  - INMARSAT, Lockheed Martin telecommunications satellite

Lewis Research Center
Technical Area - Satellite Communications
3-010

1993 Phase II, NAS3-27656, 5/98
NASA Contact - Gerald Chomos
Company Contact - Joseph Mazzochette

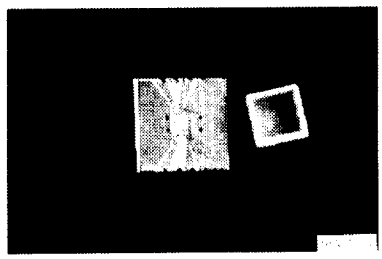
Small Business Innovation Research

Near Hermetic Packaging Technology For MMIC Devices

Foster-Miller, Inc.
Waltham, MA

INNOVATION

Excellent Electrical and barrier properties of Liquid Crystal Polymers (LCP) are exploited to provide Light Weight, Low Cost, Near-Hermetic Packages for High Frequency Applications



High Frequency LCP Package

ACCOMPLISHMENTS

- Developed processes to fabricate low loss, controlled impedance transmission lines on LCP films
- Packaged and Tested a Triquint Low Noise Amplifier (LNA) using flip chip technology. Coefficient of Thermal Expansion matched LCP substrate did not require underfilling
- Interconnected receiver circuit elements (mixer, LNA) on an LCP substrate and tested up to 20 GHz
- Packages are 50% less weight with potential to achieve 75% reduction in cost compared to hybrid technology

COMMERCIALIZATION

- Triquint Inc. interested in using the technology to package their integrated circuits
- Teledyne Electronic Technologies interested to be a vendor of substrates to the industry
- Superex, a Foster-Miller subsidiary, created to commercialize the LCP technology, added three new employees

GOVERNMENT/SCIENCE APPLICATIONS

- LCP technology is suitable for transmit/receive (T/R) modules. Applications include NASA communication satellites, and other communication satellite systems such as Iridium, Teledesic, etc.
- Use of LCP technology for packaging will reduce the cost and weight of air-borne and space-borne electronic systems
- Keen Interest to extend the technology to digital, and mixed signal applications and ball grid array, chip scale and built-up laminate technologies

Lewis Research Center
Satellite Communications
3-019

1992 Phase II, NAS3-26968, SS-, 5/98
NASA Contact - Afroz Zaman
Company Contact - K. Jayaraj

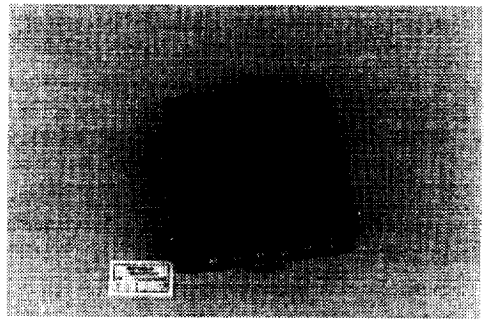
Small Business Innovation Research

Advanced Monolithic GaAs IF Switch Matrix

Microwave Monolithics Incorporated
Simi Valley, CA

INNOVATION

A 3x3 monolithic microwave integrated circuit (MMIC) switch matrix implemented in gallium arsenide for wideband (3.0 - 6.0 GHz) communications applications



6 X 6 MONOLITHIC GaAs SWITCH MATRIX

ACCOMPLISHMENTS

- Monolithic implementation using gallium arsenide switching devices achieved high isolation, low loss performance
- Modular design allowed cascading of switch matrices with little signal degradation

COMMERCIALIZATION

- MMIC technology offered ten times reduction in size, weight, and power requirements over competing technology
- A Phase III NASA Lewis contract for $1.23M was received to develop a fully integrated 6X6 switch matrix
- A 6X6 switch matrix was delivered to NASA -Lewis Research Center, which performed as specified
- Marketing this product led to substantial adjunct sales of space flight GaAs MMIC based hardware

GOVERNMENT/SCIENCE APPLICATIONS

- Demonstrated that for future wideband satellites light weight, low power switch matrices can be fabricated
- Provided a building block for future microwave integrated circuits

Lewis Research Center
Communications
3-025

1993 Phase II, NAS3-24252, 11/98
NASA Contact - Gene Fujikawa
Company Contact - Daniel Chen

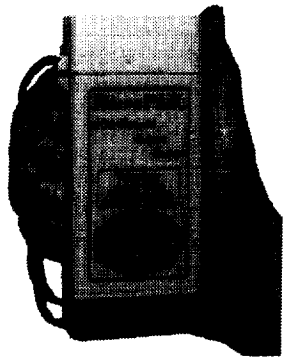
Small Business Innovation Research

High Efficiency, Low Cost Monolithic RF Module for SARSAT Distress Beacons

Microwave Monolithics Incorporated
Simi Valley, CA

INNOVATION

Miniature, ultra high efficiency GaAS MMIC components for Search and Rescue Satellite Aided Tracker (SARSAT) Distress Beacons



MicroPLB SARSAT Beacon with Internal Homing Signal and GPS Interface

ACCOMPLISHMENTS

- Developed ultra miniature Personal Locator Beacons (PLBs)
- Utilize smaller, safer batteries without performance loss

COMMERCIALIZATION

- Microwave Monolithics invested $1.2M of company resources after completion of Phase II and developed a complete MicroPLB SARSAT Beacon
- Commercial Sales of this and related technology devices exceed $1.1M to date
- Additional Government Sales of $300K directly resulted from the Phase II effort
- Substantially larger Commercial Sales projected

GOVERNMENT/SCIENCE APPLICATIONS

- The MicroPLB is a vital safety device for Military and Civilian Government personnel, providing rapid world wide notification and location information in case of emergency

Lewis Research Center
Communications
3-016

1987 Phase II, NAS3-25712, 8/98
NASA Contact - Robert Kerczewski
Company Contact - Daniel Chen

Small Business Innovation Research

Microwave-Compatible Superconducting Films

Neocera, Inc.
Beltsville, MD

INNOVATION

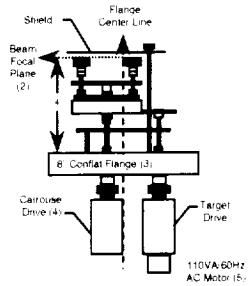
A process for growing high transition temperature superconducting films of yttrium-barium-copper-oxide on sapphire or lanthanum aluminate substrate

ACCOMPLISHMENTS

- Developed innovative pulsed laser deposition hardware
- Products developed in the process include manual multilayer deposistion systems, target carrousel flange assembly, substrate heater flange assembly, and programmable substrate heater controller

COMMERCIALIZATION

- Initial sales include $55K for pulsed laser deposition hardware and $750K for high temperature superconducting film and equipment
- Sales of all the various products developed increased to approximately $3 M
- Staff was increased from 3 to 15 people



Flange Assembly for Pulsed Laser Deposition

GOVERNMENT/SCIENCE APPLICATIONS

- For microwave engineering, procedure will reduce phase noise in planar microwave components such as local oscillators
- Size, weight, and microwave loss will be reduced when properly used in monolithic microwave integrated circuits
- The equipment developed can be used for material research at all temperatures
- High temperature superconducting films have been used as circuit switches using pulsed lasers to increase film temperature above critical temperature

Lewis Research Center
Materials

1989 Phase 2, NAS3-25929, SS-37, 8/97
NASA Contact - Thomas Kascak

Small Business Innovation Research

Innovative High Speed Modem for Satellite Communications

SiCOM, Inc.
Scottsdale, AZ

INNOVATION

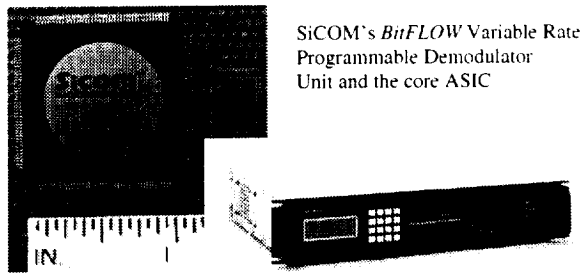
Very high integration of modem functions and flexible user programmability enabled by unique algorithm development and hardware implementation

ACCOMPLISHMENTS

- Developed the first commercially available 155 Mbps ASIC-based modulator and demodulator to enable next generation wideband video and data services
- Advanced the state of the art in modulation and coding technology demonstrating significant power and bandwidth efficient operation in a single integrated circuit
- Set the stage for successful integration of bandwidth on demand into home and office via inexpensive wireless modems

COMMERCIALIZATION

- $5M in Phase III monies through 1997 from SiCOM and Quantum Partners, LLC
- Sales projections are $3M for 1998 and $8M for 1999
- Projected 1998 -1999 growth from 47 to 100 (116%) employees
- Companies that use or have placed orders for BitFLOW 155 Mbps modems include R. E. America, Andrew Corp., NuComm, Dae Young, Raytheon TI, Wytek, I. O. Wave, VIS Technolgia, Multimedia Broadband Technologies, Triton Network Systems, Radyne and Texas Instruments



SiCOM's *BitFLOW* Variable Rate Programmable Demodulator Unit and the core ASIC

GOVERNMENT/SCIENCE APPLICATIONS

- Baseline modem for the NASA LeRC Direct Data Distribution (D^3) project
- Applicable to International Space Station and Earth Science missions which require wideband data service
- BitFLOW will be used at Sandia Labs. Other government agencies expressing interest include DARPA, NRO, DISA, USSPACECOM, and CECOM

Lewis Research Center
Satellite Communications
3-007

1994 Phase II, NAS3-27824, 3/98
NASA Contact - Monty Andro
Company Contact - Bob Putnam

TURBOMACHINERY AND PROPULSION SYSTEMS

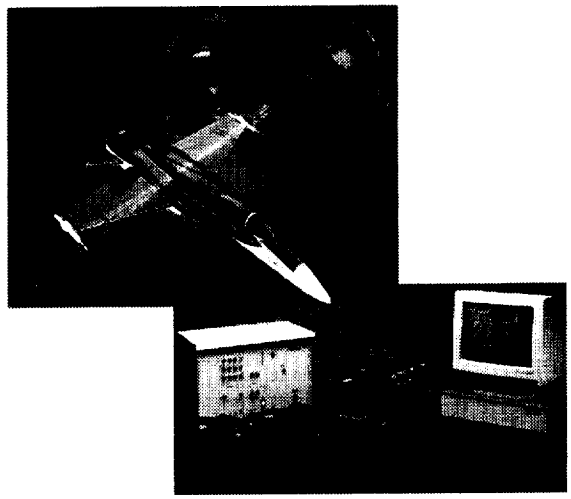
Small Business Innovation Research

Phase Doppler Particle Analyzer

Aerometrics, Inc.
Sunnyvale, CA

INNOVATION

System that provides simultaneous measurement of fuel-particle size and velocity in fuel injection systems



ACCOMPLISHMENTS

- Characterization of the complex turbulent flows in gas turbine and rocket engines
- The system includes: transmitting and receiving optics, a signal processor, system software, and a fiber drive
- This non-intrusive device has created great interest in the commercial sector attested to by its selection for the international Tanasawa Award

COMMERCIALIZATION

- Spray nozzle development for fuels, paints, agricultural materials, and medical nebulizers
- Commercial sales - more than $25 million (over $5M per year)
- Providing over 120 jobs at Aerometrics and its suppliers and distributors

GOVERNMENT/SCIENCE APPLICATIONS

- Used in the characterization of particle fields by NASA's Icing Technology Division
- Program uses include advanced subsonic transport (AST) and high speed research (HSR)

Lewis Research Center
Aeropropulsion

1995 Phase II, NAS3-25204, SS-39, 10/16/95
NASA Contact - Valerie Lyons

Small Business Innovation Research

Simultaneous Measurement of Temperature, Size, and Velocity of Drops in Sprays

Aerometrics, Inc.
Sunnyvale, CA

INNOVATION

An instrument which measures temperature, size and velocity of drops in sprays using rainbow refractometry/thermometry

ACCOMPLISHMENTS

- This laser-based, non-intrusive diagnostic instrument can measure temperature (refractive index) of individual spherical droplets in complex reactive sprays while simultaneously measuring size and velocity
- Applications have included burning droplet streams, swirl-stabilized spray flames, and multi-component non-reactive sprays

COMMERCIALIZATION

- Received orders for $500K worth of equipment in July 1995
- Sold to universities (Carnegie Mellon) for use on spray combustion studies
- Sold to aerospace industry for use in rocket injector studies
- Inquiries from Japan, China, France, and Korea
- Contributed to an expanded new location

GOVERNMENT/SCIENCE APPLICATIONS

- High Speed Research (HSR), Advanced Subsonic Transport (AST), icing and in rocket injector research and gas turbine combustion research
- Prototype rainbow thermometer delivered to Lewis and integrated with existing two component Phase Doppler Particle Analyzer

Lewis Research Center
Aeropropulsion

1988 Phase 2, NAS3-26248, SS-109, 3/29/96
NASA Contact - Mark Klem

Small Business Innovation Research

Single Lever Power Control for General Aviation and Unmanned Aircraft

Aurora Flight Sciences Corporation
Manassas, Virginia

INNOVATION

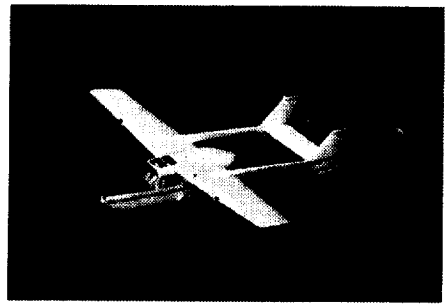
Pilot or Autopilot controls General Aviation or Unmanned Air Vehicle (UAV) propulsion system via a Single Lever or a Single Power Command using a FADEC (Full-Authority Digital Engine Control) with optimal propeller/engine control

ACCOMPLISHMENTS

- Developed first FADEC with full-digital Single Lever Power Control (SLPC) for General Aviation (GA) aircraft with optimal propeller/engine control
- Developed and flight-tested the SLPC-FADEC system in GA aircraft - showed over 20% fuel consumption improvement
- Tested FADEC system with UAV engine in test cell to 68,000 ft altitude
- FADEC-controlled engine propels the *Perseus B* high-altitude UAV to 60,000 ft altitude

COMMERCIALIZATION

- Joint ventures with Athena Technologies combines SLPC with advanced flight controls and FTC (Fault-tolerant Control) algorithms
- FADEC-controlled engines operated in excess of 500 hours in test cells and in flight
- Ideal propulsion control unit for General Aviation naturally aspirated and turbocharged singles, twins, turboprops and other transportation propulsion systems



Aurora's Chiron aircraft with full-digital Single Lever Power Control

GOVERNMENT/SCIENCE APPLICATIONS

- Currently being used in NASA's AGATE (Advanced General Aviation Transport Experiment) for integrated flight tests with all-digital cockpit technology components
- Potentially used in NASA's ERAST (Environmental Research and Atmospheric Science Technology) UAV program

Glenn Research Center
General Aviation
3-031

1994 Phase II, NAS3-27614, 2/99
NASA Contact - Donald Simon
Company Contact - Benjamin Russ

Small Business Innovation Research

Unstructured Adapted Meshes

Creare, Inc.
Hanover, NH

INNOVATION

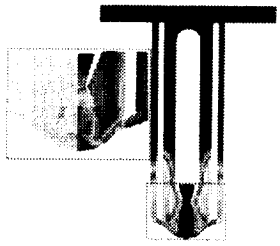
Computer software for the solution of compressible flows using unstructured grids

ACCOMPLISHMENTS

- Developed a general purpose computer program for computational fluid dynamics
- Unstructured solution-adaptive grids have been applied to a wide variety of problems including aircraft, turbomachinery, automobiles, internal combustion engines, missiles, parachutes, etc.

COMMERCIALIZATION

- Commercialized as the product RAMPANT™
- Well over $1M worth of licenses for RAMPANT™ have been sold
- Creare created a new software company, Fluent Inc. to market RAMPANT™ and several other CFD software products that were developed, in part, with NASA SBIR funding
- Fluent currently employs over 200 people and has annual revenues in excess of $30M. It was recently sold to Aavid Thermal Technologies, which is a large company



Mass fraction of exhaust gases and prediction of Mach number during confined launch of a rocket

GOVERNMENT/SCIENCE APPLICATIONS

- Solution of fluid flow problems and the design of flight vehicles using physical models that address turbulent flows, heat transfer, compressible mixing, chemical reaction, and flows with strong shocks

Lewis Research Center
Aeronautics
3-015

1987 Phase II, NAS3-25785, 8/98
NASA Contact - Rodrick Chima
Company Contact - Peg Ackerson

Small Business Innovation Research

Advanced CFD Tools for Designing Combustion Systems & Materials Processing

Daat Research Corp.
Hanover, NH

INNOVATION

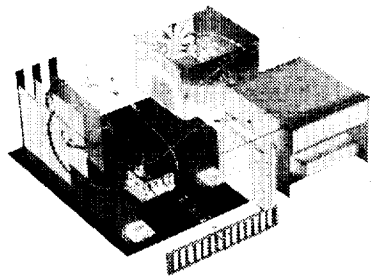
A fast, compact, PC-based code for analyzing combustion and materials processes

ACCOMPLISHMENTS

- A first of its kind, fast code for complex chemically reacting flows in arbitrary geometries
- Ability to run efficiently on MS-Windows PCs
- Custom versions developed for optimizing certain processes such as nozzle flows and fiber manufacturing for composites applications

COMMERCIALIZATION

- Based on the developed technology, Daat produced Coolit - a unique CFD code for electronics cooling applications
- Within two years, Coolit made major progress against well-entrenched competition increasing its sales exponentially and signing new clients world-wide
- Some of the world's best companies such as Boeing, Raytheon, Lockheed-Martin, Teradyne, ECT Telecom and many others now rely on Coolit for their thermal design needs



Example of Results for Electronics Cooling

GOVERNMENT/SCIENCE APPLICATIONS

- Highly compact and efficient code for designing and optimizing reactive flows in nozzles and in manufacturing processes for composite fibers
- Used in support of high speed research (HSR), and microgravity programs
- The commercial code, Coolit, is used in thermal design of electronics

Lewis Research Center
Aeronautics
3-028

1992 Phase II, NAS3-27251, 12/98
1992 Phase II, NAS3-26848
NASA Contact - Ajmon Chait/Jeff Moder
Company Contact - Arik Dvinsky

Small Business Innovation Research

Improved Electroformed Structural Copper and Copper Alloys for Rocket Components

Electroformed Nickel, Inc.
Huntsville, AL

INNOVATION

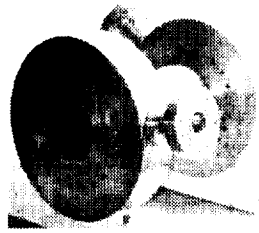
Improvements in mechanical properties of electrodeposited copper by conversion of coarse columnar grains into fine equi-axed grain structures and use of secondary strengthening methods such as alloying and dispersion strengthening

ACCOMPLISHMENTS

- Mechanical properties of electroformed copper equivalent to those of wrought nickel have been demonstrated (a 50% improvement over prior electroformed copper)
- Elevated temperature ductility of electroformed copper to 500°F has been improved three fold
- Copper-platinum and copper-silver alloys have been developed having potential for even higher temperature use
- A full scale regeneratively cooled copper tube bundle thrust chamber was fabricated entirely by electroforming with the new copper to demonstrate that property degrading thermal joining methods could be eliminated

COMMERCIALIZATION

- To date $17K of these new materials have been sold to NASA Lewis Research Center
- Pratt & Whitney is examining test samples for potential use in light-weight, high-performance reusable launch vehicles



NASA All Copper Compliant Tube Regen Chamber Electroformed using new High Strength Materials

- NASA Tech Brief descriptions of the new materials are being prepared as a beginning of a marketing effort. Professional journal and symposium papers are planned, as well as person-to-person discussions with design engineers of major aerospace and defense contractors
- Within the coming year, employment of additional staff members is anticipated as this new material is required under new contracts

GOVERNMENT/SCIENCE APPLICATIONS

- Dialogue has already begun with Boeing's Rocketdyne Division where Space Shuttle Main Engine upgrades are in planning
- Potential market will include DOD where new, improved shaped charge liners for warheads is sought

Glenn Research Center
Turbomachinery
3-020

1992 Phase II, NAS3-27386, 5/99
NASA Contact - Tim Smith
Company Contact - Glenn Malone

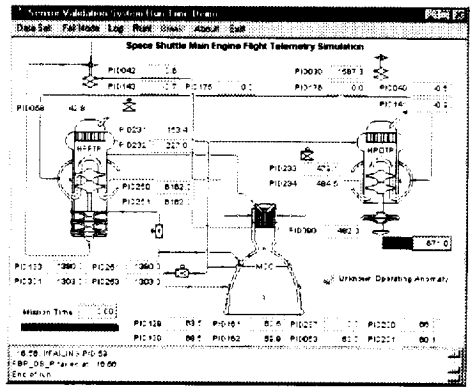
Small Business Innovation Research

Real-Time Sensor Validation

Expert Microsystems, Inc.
Orangevale, CA

INNOVATION

Real-time decision algorithm enables very high reliability sensor failure detection for safety critical control systems.



Space Shuttle Main Engine (SSME) Real Time Sensor Validation

ACCOMPLISHMENTS

- Prototype system validates 15 Space Shuttle Main Engine (SSME) sensors in real-time
- SSME prototype reliably detects sensor failures from Start to Shutdown command
- Embedded in Boeing's Advanced Fault Tolerant Flight Computer and successfully tested
- Embedded in Lockheed-Martin's Modular Rocket Engine Control Software and successfully tested

COMMERCIALIZATION

- Follow-on contracts from NASA totaling $300,000 have created two full time equivalent jobs in 1997/98
- Commercial applications in chemical process and power generation industries anticipated

GOVERNMENT/SCIENCE APPLICATIONS

- Under development for real-time Space Shuttle telemetry data analysis and NASA mission operations support
- Under evaluation for military aeropropulsion system data monitoring

Lewis Research Center
Space Propulsion
3-012

1994 Phase I, NAS3-27484, 6/98
NASA Contact - June Zakrajsek
Company Contact - Randall Bickford

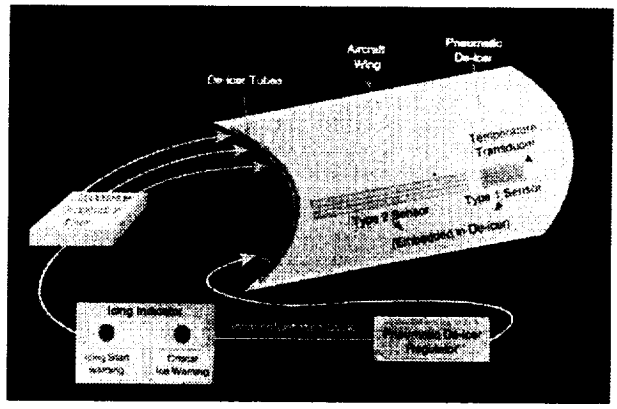
Small Business Innovation Research

Ice Detection Sensor System

Innovative Dynamics, Inc.
Ithaca, NY

INNOVATION

An integral sensor/de-icer system will enable pilots to validate de-icer inflation and to determine if accreted ice has shed after system operation



Automated ice protection system

ACCOMPLISHMENTS

- The IDI sensor system will be integrated into B.F. Goodrich pneumatic de-icers to achieve significant advances in early ice detection, bringing ice detection technology to the general aviation market at an affordable price

COMMERCIALIZATION

- System has potential market value of $40-100M
- Market size of 20,000 to 50,000 general aviation aircraft
- Other applications include detection of ice on runways, highways, bridges, antennas and power lines
- B.F. Goodrich has acquired a license to the technology and patent rights for system

GOVERNMENT /SCIENCE APPLICATIONS

- Research supported by Icing Technology Branch within NASA Lewis Research Center
- Piper Malibu featured at September 94 icing technology open house

Lewis Research Center
Icing Technology

1988 Phase 2, NAS3-25966 SS-34 10/17/95
NASA Contact - Andrew Reehorst

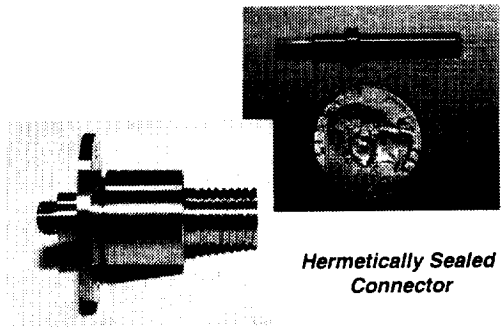
Small Business Innovation Research

Fiber Optic Cable Feedthrough and Hermetic Sealing for Aerospace Environment

LiteCom, Inc.
Canoga Park, CA

INNOVATION

Fiber optic sealing material that provides cryogenic hermetic sealing up to 10^{-11} cc/sec Helium leak rate in both feedthroughs and connectors



Hermetically Sealed Connector

ACCOMPLISHMENTS

- Designed and developed feedthroughs which demonstrated 10^{-11} cc/sec helium leak rate at temperatures from -196°C to +200°C
- Successfully used in vibration, thermal shock, salt spray, humidity, mechanical shock, neutron fluence radiation, gamma radiation, and ion radiation tests
- Created great interest in the commercial and military underwater applications for hermetic seals

COMMERCIALIZATION

- Hermetic sealing material development for fiber optic transmission between harsh environments such as refineries, nuclear power plants, aircraft, mines, security systems, petrochemical processing, ships, and corrosive environments
- Commercial sales - more than $1M
- Providing 5 jobs at LiteCom and its suppliers

GOVERNMENT/SCIENCE APPLICATIONS

- Provided hermetically sealed underwater connectors for use with Navy submarines, submersibles, and remotely operated vehicles
- Provided fiber optic hermetic sealed connectors for Sandia Laboratory
- Potential for Space Station application

Lewis Research Center
Instrumentation and Controls
3-009

1990 Phase II, NAS3-26611, 5/98
NASA Contact - Amy Jankovsky
Company Contact - Robert Farr

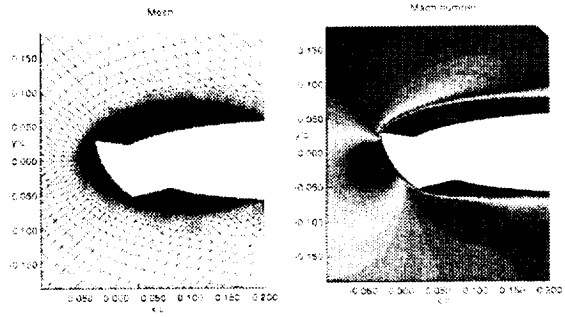
Small Business Innovation Research

Unsteady Triangular Mesh/Navier-Stokes Method for Aerodynamics of Aircraft with Ice Accretion

Nielsen Engineering & Research, Inc.
Mountain View, CA

INNOVATION

Combining an adaptive grid method with Navier-Stokes computer code for predicting ice growth on aircraft and performance degradation



NACA 0012 Airfoil with Simulated Glaze Ice
$M_\infty = 0.12$, $\alpha = 4°$

ACCOMPLISHMENTS

- Developed computation capabilities to study effects of ice on the aerodynamics of aircraft wings

COMMERCIALIZATION

- Received $42K in direct sales
- Improved capabilities in an area that did not previously exist with the company; hence, company was able to obtain additional work

GOVERNMENT/SCIENCE APPLICATIONS

- Useful in studies and design for commercial and general aviation for reducing ice accretion

Glenn Research Center
Aeronautics
3-030

1998 Phase II, NAS3-26059, 1/99
NASA Contact - Mark Potapczuk
Company Contact - Michael R. Mendenhall

Small Business Innovation Research

Catalytic Ignition for Rotary Combustion Engines

Precision Combustion
New Haven, CT

INNOVATION

Catalytic glow plugs and catalytic surface technology for internal combustion engines and gas turbines

Glowplug

ACCOMPLISHMENTS

- Significantly reduced gaseous and white smoke emissions in rotary engines, as well as improved efficiency and stability
- Demonstrated durability advantages of catalytic glow plugs vs. conventional glow plugs
- Proved concept of using catalytic engine coatings under severe thermal fatigue

COMMERCIALIZATION

- Advances in program led to developments in catalytic ignition systems receiving $2.6M in further R&D investment from both government and commercial sources
- Precision Combustion, Inc. is working with major diesel engine manufacturers to implement catalytic glow plugs for new engine design, with Phase III investment more than $300K
- Company increased in size from 1 employee to 5 employees

GOVERNMENT/SCIENCE APPLICATIONS

- Technology enabled further catalytic combustor advances by Precision Combustion, Inc. for DARPA, NASA, US Army, and USAF
- Catalytic ignitors for improved combustion stability to prevent flame out during rapid acceleration and deceleration of aircraft engines
- Catalytic combustors for ultra-low emission gas turbine engines

Lewis Research Center
Aeropropulsion

1986 Phase 2; NAS3-25784, SS-160; 3/24/97
NASA Contact - Chi Ming Lee

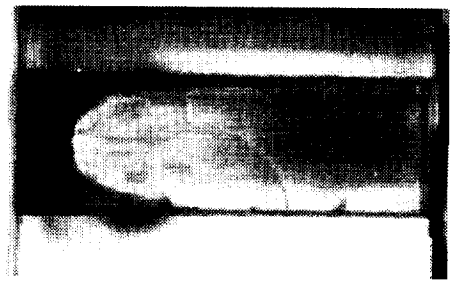
Small Business Innovation Research

A Novel Approach to Catalytic Combustion

Precision Combustion
New Haven, CT

INNOVATION

Advanced catalytic conbustor for aeropropulsion and ground based engines



Catalytic Combustion Flame

ACCOMPLISHMENTS

- Demonstrated Ultra-low No_x, CO, and Unburned Hydrocarbons (UHC) emissions for High Speed Civil Transport applications
- No_x emissions were demonstrated at steady-state to be 1/3 to 1/5 of regulatory targets

COMMERCIALIZATION

- Multimillion dollar long term catalytic combustor development and supply agreement between Westinghouse Power Generation and Precision Combustion, Inc
- Precision Combustion Inc.'s catalytic combustor for Equivalent Zero Emission Vehicles is in an automotive application engine test program with Capstone Turbine Corporation
- Non-government Phase III funding of more than $500K for ultra-low NOx emissions catalytic combustors for ground base gas turbine hybrid electric vehicles
- Employment increased from 5 to 30 employees

GOVERNMENT/SCIENCE APPLICATIONS

- Ultra-low NOx aircraft and ground power catalytic combustion
- Catalytic combustors for clean hybrid electric vehicles
- Ignition and combustion stability enhancement for aerospace engines

Lewis Research Center
Aeropropulsion

1990 Phase II, NAS3-26614, SS-161; 3/97
NASA Contact - Chi Ming Lee

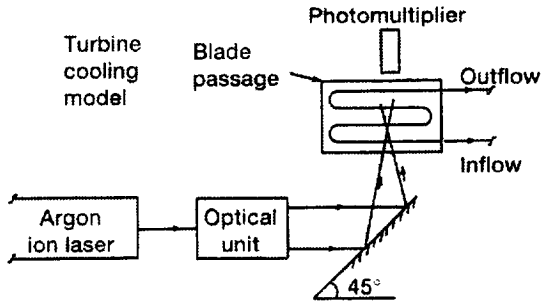
Small Business Innovation Research

Flow in Turbine Blade Passages

Scientific Research Associates, Inc.
Glastonbury, CT

INNOVATION

The use of refractive index matching laser velocimetry to obtain detailed mean and turbulent flow fields



Laser-Doppler Velocimeter Set-up - Forward Scattering

ACCOMPLISHMENTS

- Obtained knowledge of flow fields required to achieve goals
- Flow field measurements provided a nice compliment to previously acquired heat transfer from a model of similar geometry
- Simulations were compared to experimental velocity fields
- Combined computational-experimental program provided new insight into structure of flow field

COMMERCIALIZATION

- Generated $240K in Government Non SBIR/STTR Funds
- UTRC collaborated in the program by providing model geometry and heat transfer data
- Pratt and Whitney performed the computational calculations

GOVERNMENT/SCIENCE APPLICATIONS

- New design tool for the development of turbine blade internal cooling configurations
- Rotating flow field database useful for simulation code validation

Lewis Research Center
Aeronautics
3-013

1989 Phase I, NAS3-26251, 5/98
NASA Contact - Philip Poinsatte
Company Contact - Dr. Harold L. Grubin

Small Business Innovation Research

High Temperature Oxidation-Resistant Thruster Materials

Ultramet
Pacoima, California

INNOVATION

Very high temperature iridium/rhenium metal coatings and free-standing structural shapes produced by a unique chemical vapor deposition (CVD) process.

Molybdenum Mandrel and Completed Ir/Re Chambers

ACCOMPLISHMENTS

- Advanced the state-of-the art in materials and processes for the fabrication of liquid bipropellant chemical rocket thrust chambers, permitting operation at higher temperatures for longer time periods and thereby providing a significant increase in performance
- Demonstrated process scaleup to larger chamber sizes
- Developed and characterized the fabrication process to permit application of this technology to satellite and spacecraft propulsion systems

COMMERCIALIZATION

- NASA, TRW/Lockheed Martin, Kaiser Marquardt/Hughes, Aerojet, and Ultramet have invested nearly $20 million to develop this technology
- Flight qualification has been completed at Kaiser Marquardt, with first flight on a Hughes communications satellite scheduled in 1998
- To date, 4 jobs at Ultramet and 1 job at Kaiser Marquardt have been created

GOVERNMENT/SCIENCE APPLICATIONS

- Through increased thruster performance, communications satellite owners/operators will realize $30-60 million in added revenue
- Apogee kick and station-keeping thrusters for satellites in geostationary orbit and thrusters for spacecraft propulsion systems
- Rocket nozzles, turbomachinery, and aircraft turbine engine components

Lewis Research Center
Materials

1985 Phase II, NAS3-25203, SS-176, 11/97
NASA Contact - Steve Schneider

Small Business Innovation Research

High Temperature Turbine Blades

Ultramet
Pacoima, CA

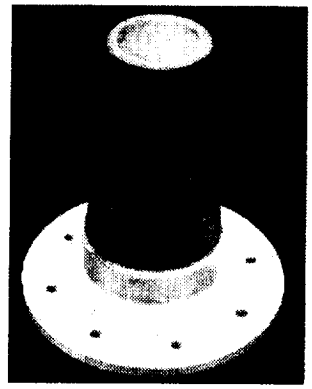
INNOVATION
Net-shape fiber-reinforced metal matrix composite turbine blades, produced by a unique chemical vapor infiltration (CVI) process

ACCOMPLISHMENTS

- Evaluated continuous refractory fibers as strengthening reinforcements for niobium metal matrix
- Developed controllable, repeatable process for infiltrating niobium metal matrix into fiber preforms
- Ultimately spun off technology into fabrication of load-bearing, hermetically sealed ceramic-to-metal joints for use in high temperature propulsion systems

COMMERCIALIZATION

- Ceramic-to-metal joints fabricated for BMDO/Army Theater High Altitude Air Defense System (THAADS), with $750K in sales to date to propulsion contractor (Rocketdyne)
- Ceramic-to-metal joints fabricated for DOE/Navy submarine nuclear reactor program, with $500K in sales to date to industry contractor (GE/Knolls Atomic Power Laboratory)
- To date, 3 new jobs have been created at Ultramet



Ceramic Composite Thrust Chamber with Metal Flange Attachment

GOVERNMENT/SCIENCE APPLICATIONS

- Aerospace propulsion and power systems, including intercept vehicles for missile defense, nuclear submarine reactors, advanced aircraft turbine engines and liquid rocket turbomachinery

Lewis Research Center
Materials

1987 Phase II NAS3-25660, SS-178 8/97
NASA Contact - Joni Kazaroff

STRUCTURES

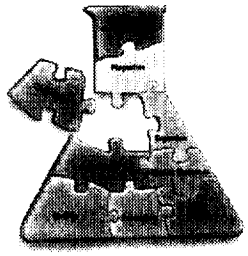
Small Business Innovation Research

Design of Experiments Module

AI Ware, Inc.
Cleveland, OH

INNOVATION

A general purpose computational method using artificial intelligence that selects experiments required to develop a design model



Design of Experiments Module

ACCOMPLISHMENTS

- Developed a Design of Experiments module for enhanced computational methods
- Scientific community recognized this product as a very useful contribution for re-designing experiments and hence reducing experiment costs
- Company was selected by readers of R&D magazine as a winner in the 1994 R&D ELITE Awards Program

COMMERCIALIZATION

- Experiments module is tentatively scheduled for commercial release in mid-1995 along with the introduction of CAD/Chem Version 4.2
- Diverse customer base includes: pharmaceuticals & medical (Eli Lilly and Company), chemicals (S.C. Johnson Wax), , plastics (B.F. Goodrich & Dow Chemical), paint & coatings (The Glidden Paint Company)
- Contributed $100K to sales, and this contribution is increasing

GOVERNMENT/SCIENCE APPLICATIONS

- The computer program which incorporates artificial intelligence can be applied to any experimental designing used in the scientific and research communities
- This method is presently being used in Lewis Research Center's Structural Analysis program
- Also used at Wright Patterson AFB in the composites area

Lewis Research Center
Structures

1990 Phase 2; NAS3-26657; SS-27; 8/2/96
NASA Contact - Laszlo Berke

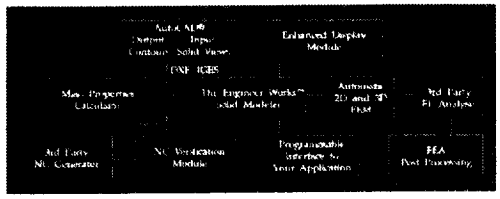
Small Business Innovation Research

Autosolid

Cadetron, Inc.
Atlanta, GA

INNOVATION

An expert system that utilizes CAD capabilities to create a finite element model for use by those who are not experts in Finite Element analysis



Information Flow of Finite Element Analysis

ACCOMPLISHMENTS

- A solid modeler was developed and integrated with an internal advisory expert system to automatically transform it into a finite element model and to perform structural analysis

COMMERCIALIZATION

- The product caught the interest of AUTODESK, the world's largest CAD/CAM software company before the contract end date and they bought Cadetron
- The solid modeler was first released as AUTOSOLID then as the "Advanced Modeling Extension" (AME) to the AutoCAD product. Sales of this product resulted in several million dollars of revenue.

GOVERNMENT/SCIENCE APPLICATIONS

- Has been used in NASA Lewis's structural analysis research
- Innumerable applications for product design within the AutoCad system

Lewis Research Center
Structures
3-008

1995 Phase 2; NAS3-25150; SS-125; 3/12/96
NASA Contact - Laszlo Berke
Company Contact - Robert Holt

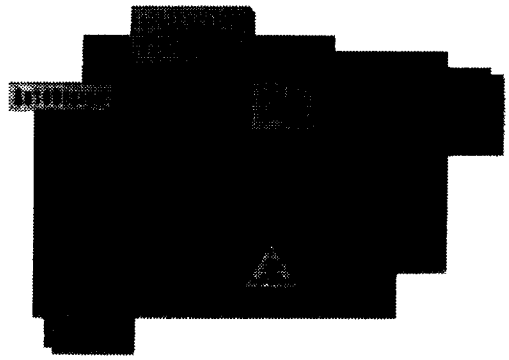
Small Business Innovation Research

AUTODESIGN

Structural Analysis Technologies, Inc.
Santa Clara, CA

INNOVATION

Integration of solid modeling, structural analysis/optimization with Expert System Advisor



AUTODESIGN architecture

ACCOMPLISHMENTS

- AUTODESIGN is a structural optimization and design software which is unique in the market because of its Expert System knowledge based content

COMMERCIALIZATION

- Structural Analysis Technologies has partnered with AUTODESK, the world's largest CAD/CAM software company, to market AUTODESIGN
- Approximately 500 copies were sold by Structural Analysis Technologies, with sales totaling nearly $2 M
- SAT, together with AUTODESK are part of the winning team for the $900 M Navy NAVFAC software contract. SAT's portion of the contract is $5M with a maximum up to $7M.

GOVERNMENT/SCIENCE APPLICATIONS

- Used at Lewis Research Center and Edwards AFB in design of new generation aerospace structures
- Used by Hughes Aircraft, TRW, Applied Materials, Lockheed, Sandia Labs, and Kelly AFB, as well as other firms and government organizations for mechanical and aerospace design

Lewis Research Center
Structures

1987 Phase II: NAS3-25642, SS-28, 8/20/97
NASA Contact - Laszlo Berke

Small Business Innovation Research

High Reliability Long-Term Lubricators

The Technology Partnership
Grosse Ile, MI

INNOVATION

Dispensing lubricant for multi-year durations using the viscoelastic effects of polymers

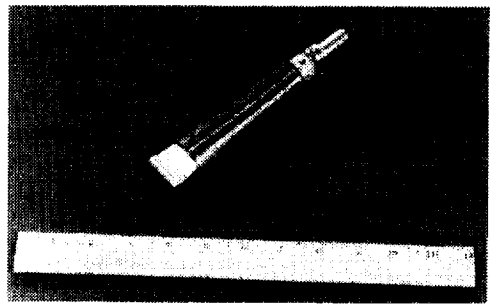


Photo courtesy of TACOM - Glen Steele
Shrink-Polymer Dispenser

ACCOMPLISHMENTS

- Developed long term time-dependent shrink-polymers for dispensing lubricants
- Validated a new use for shrink-polymers as implants for long term drug-infusion pumps
- Patents obtained for new shrink-polymer applications

COMMERCIALIZATION

- A major automotive supplier has committed for $500K in follow-on funding for an annual automotive market estimated at $100M annually
- Major drug companies are evaluating a universal drug-dispensing implant that uses viscoelastic technology
- Subsequent Phase I and II SBIR awards from both Army Tank automotive and Armaments Command (TACOM) and the Air Force based on shrink-polymers

GOVERNMENT/SCIENCE APPLICATIONS

- Assured lubrication of satellite spin-motors with 80% reduction in lift weight over mechanical lubricators
- Lubricator has the potential to make substantial improvements in maintenance costs and reliability of U.S. Army tactical vehicles

Lewis Research Center
Materials

1992 Phase I, NAS3-26844, SS-181, 8/97
NASA Contact - Robert Fusaro

MICROGRAVITY

Small Business Innovation Research

A Capacitive Void Fraction Instrument for Two-Phase Flow in Microgravity

Creare, Inc.
Hanover, NH

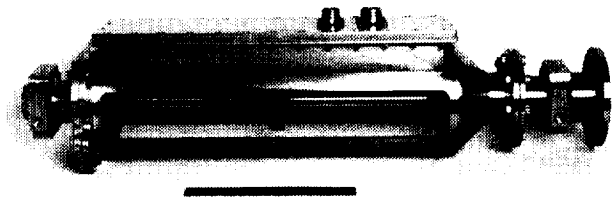
INNOVATION
Non-intrusive instrument for measurement of volume-averaged or local void fraction with refrigerants (dielectric fluids)

ACCOMPLISHMENTS

- Proved non-intrusive design approach
- Developed stable, accurate electronics and signal conditioning
- Demonstrated instrument on microgravity aircraft
- Space-qualified instruments delivered
- Continuing to support microgravity aircraft flights in 1998/99 (KC-135) with the design/development of instruments of various internal diameters

COMMERCIALIZATION

- Sold approximately $500K worth of these instruments to NASA for various science missions to date
- Instrument can be used in a gravity environment. Have had negotiations with some companies for use in gravity



Space-Qualified Version of Creare Void Fraction Instrument

GOVERNMENT/SCIENCE APPLICATIONS

- Used in microgravity science missions aboard the NASA KC-135 aircraft:
  - To measure flow characteristics (local/avg. void fractions and wall shear stress) in a R-134a refrigerant loop by NASA LeRC Microgravity Division
  - To measure flow characteristics in R-134a and R-12 refrigerant loops by NASA JSC Crew and Thermal Systems Division (with Texas A&M University)

Lewis Research Center
Microgravity
3-014 OD-98-77710

1991 Phase II, NAS3-26552, 7/98
NASA Contact - Myron Hill
Company Contact - Christopher J. Crowley

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13. ABSTRACT ***(Maximum 200 words)***

This booklet of success stories summarizes the NASA Glenn Research Center's accomplishments and successes by the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. These success stories are the results of selecting projects that best support NASA missions and also have commercialization potential. Each success story describes the innovation accomplished, commercialization of the technology, and further applications and usages. The company name and the NASA contact person are identified to encourage further interest and communication to occur.

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