Abstracts of Awards for Fiscal Year 2000 NIST SBIR Program

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FY 2000 Phase I Award

**Topic:** 8.6 Adaptive Learning Systems

**Subtopic:** 8.6.1T Distributed Interactive Learning

**Title:** Application Frameworks and Simulation Components for Intelligent Tutoring

**NIST OU:** 890

**Firm:** Stottler Henke Associates, Inc. (SHAI)
1660 So. Amphlett Boulevard Suite 350
Mateo, CA 94402

**Principal Investigator:** Richard Stottler
**Phone:** 650-655-7242

**Award Amount:** $75,000.00

**Abstract:** Intelligent Tutoring Systems (ITSs) strive to provide the benefits of one-on-one instruction automatically and cost-effectively. Like training simulations, ITSs enable students to apply their knowledge and hone their skills by carrying out tasks within highly interactive learning environments. However, ITSs go beyond training simulations by also monitoring the student's actions, assessing his or her performance, and providing helpful hints and feedback. Despite the effectiveness of ITSs, relatively few ITSs are in operational use, compared to the number of traditional computer-based training systems which have been deployed. This is largely due to the high cost of developing the simulator portion of ITSs. SHAI proposes to develop task-specific tutoring system engines and authoring tools which can incorporate pre-built simulation components. Each tutoring system and authoring tool will enable a subject matter expert or instructor to create tutoring systems more quickly and easily than is currently possible, by configuring and incorporating these pre-built components within the appropriate task-specific application framework. Designing each tutoring system architecture to support a specific abstract task makes it possible to create authoring tools which provide more guidance to the author, and simplifies the integration of simulation components with the tutoring system engine.

**Commercial Applications:** This technology will lower the cost of developing web-based ITSs and will support the commercialization of tutoring system engines, authoring tools, instructional simulation components, and turnkey ITS applications which serve horizontal markets, vertical industry markets, and individual companies.

**FY 2000 Phase I Award**

**Topic:** 8.7 Advanced Building Materials and Systems

**Subtopic:** 8.7.1T Direct Electrical Measurement of Cement Hydration

**Title:** Time-Domain-Reflectrometry Frequency-Probe Sensor System to Measure Degree of Hydration in Cementitious Materials

**NIST OU:** 860

**Firm:** Materials Sensing and Instrumentation, Inc.
772 Dorsea Road
Lancaster, PA 17601-2212

**Principal Investigator:** Nathaniel Hager III
**Phone:** 717-361-1377

**Award Amount:** $74,928.29

**Abstract:** This project will demonstrate an in-situ cure sensor for continuously monitoring internal moisture and hydration reactions in curing concrete. It uses a modified form of Time-Domain-Reflectometry, which extracts frequency information from sensor response, and thus probes microwave molecular dynamics. The sensor response is captured in a fast voltage transient and either Fourier-Transformed to the frequency domain for a detailed research-grade measurement, or interpreted directly in the time domain for a robust field-grade measurement. Signals for free- and bound-water response are separated due to differences in response time. Phase 1 will demonstrate this approach, a sensor will be devised which can detect the signal in situ, free- and bound-water signals will be separated and identified through appropriate dielectric modeling, and each signal will be monitored during controlled cure and correlated with analytical methods.

**Commercial Applications:** The commercial potential of this work will be a concrete cure sensor that provides continuous readout of moisture and hydration both in the laboratory and the field. This could lead to lower construction costs through elimination of excessive wait times and design safety factors to compensate for uncertain quality control. The work draws on much experience in our laboratory in Time-Domain-Relectometry process monitoring.

**FY 2000 Phase I Award**

**Topic:** 8.7 Advanced Building Materials and Systems

**Subtopic:** 8.7.2T Software Package for Optimizing Refrigerant Circuitry in Finned-Tube Condensers

**Title:** An Intelligent System for Optimizing Refrigeration Circuitry in Finned-Tube Condensers

**NIST OU:** 860

**Firm:** International Intelligent Systems, Inc.
9711 Maury Road
Fairfax, VA 22032-2836

**Principal Investigator:** Kenneth Kaufman
**Phone:** 703-764-9142

**Award Amount:** $74,940.00

**Abstract:** This project applies the state-of-the art methods of evolutionary computation and machine learning to develop a system for designing optimized refrigerant circuitry in finned-tube condensers. We will study a feasibility of building a software package that would assist engineers in designing condensers of the maximum capacity for the specified parameters. To this task, we will apply a novel form of evolutionary computation, called **Learnable Evolution Model (LEM)**. In contrast with conventional computation methods that apply semi-blind operations of mutation and/or recombination to obtain new designs, LEM applies a reasoning process involving hypothesis generation and instantiation. At each step of evolutionary design, alternative designs are generated and evaluated by a condenser simulator. The designs are classified to two groups: high-performance and low-performance. A learning system generates hypotheses characterizing differences between the two groups. These hypotheses are then instantiated to new designs. This process is conducted repeatedly until a satisfactory design is obtained, or a termination condition is met. Our experience in applying LEM to designing evaporators for heat exchangers have shown the high practical potential of such an approach. Deliverables will include results from the feasibility study of the methodology, and a preliminary software package for designing optimized circuitry of condensers.

**Commercial Applications:** The proposed methodology and system will lay foundations for the development of an industrial strength system. Since the ISHED system for heat exchanger design, previously developed by INIS, has shown the ability to outperform the best human designs, it is expected that similar performance will be achieved with the proposed system. In view of the wide use of condensers in the industry and private homes, potential benefits from this project in terms of savings energy may be huge due to more efficient designs of condensers.

**FY 2000 Phase I Award**

**Topic:** 8.8 Advanced Detection and Suppression of Fires

**Subtopic:** 8.8.7T Fire Fighter Locator

**Title:** Ultra-Wideband Wireless Fire Fighter Locator

**NIST OU:** 860

**Firm:** Intelligent Automation, Inc.
2 Research Place Suite 202
Rockville, MD 20850

**Principal Investigator:** Dr. Len Haynes
**Phone:** 301-590-3155

**Award Amount:** $75,000.00

**Abstract:** The key innovation of this proposal is the use of Time Modulated Ultra-Wideband (TM-UWB) technology to develop a low-cost radio system that allows both voice communication and tracking positions of hundreds of fire fighters inside or outside buildings. Intelligent Automation (IAI) is working with a partner company, Time Domain, Corporated (TDC), to develop and apply a new type of radio called Time-Modulated Ultra-WideBand radio. This radio has several characteristics which make it ideal for tracking multiple individuals from inside to outside a building without line-of-sight. What we propose will exceed the solicitation requirements in that it will also provide voice communication, low probability of intercept, difficult-to-jam voice and data communication with no additional hardware over the basic tracking system. We will call the system we propose **Ultra Radio**.

**Commercial Applications:** IAI's role will be designing, building, and commercializing the Ultra radio system using TDC components for the kernel functions.

* Potential customer needs - A way to track many participants moving within some defined area.
* Potential customers - The military for training activities or actual operations, fire fighters, and police.
* What is done today - GPS can be used but is inaccurate, susceptible to jamming and interruption by noise and will not penetrate foliage or inside buildings.

Market size - Large, including commercial applications such as police and fire fighters.

**FY 2000 Phase I Award**

**Topic:** 8.8 Advanced Detection and Suppression of Fires

**Subtopic:** 8.8.10T Drop Size and Velocity in Industrial Fire Sprinklers

**Title:** Real-time Technique to Measure Particle Size and Velocity of Polydisperse Sprays with Large Dynamic Size Range

**NIST OU:** 860

**Firm:** MetroLaser Inc.
18010 Skypark Circle #100
Irvine, CA 92614-6428

**Principal Investigator:** Dr. Cecil Hess
**Phone:** 949-553-0688

**Award Amount:** $74,982.00

**Abstract:** This is a proposal to develop a technique to simultaneously measure particle size, velocity, and concentration in applications characterized by a large size range and high particle concentration. The technique is superior to currently available methods in its ability to measure particle size over a very broad dynamic range, its small probe volume that allows high particle concentration measurements, and its ability to measure nonspherical particles. The technique bases its measurement on accurate time-domain algorithms. Measurements with calibrated glass beads and calibrated liquid sprays show a remarkable accuracy that places the measurement within manufacturer's tolerances. Analytical and experimental studies will be conducted during Phase 1 to demonstrate the feasibility of measuring the required size range and concentration characteristic of fire sprays.

**Commercial Applications:** The laser-based technique proposed here should have broad commercial applications given its large dynamic range and its ability to measure either liquid or solid particles. Potential users include industries and Government agencies interested in spray atomization and powder technology such as food, pulverized coal combustion, and sand blasting.

**FY 2000 Phase I Award**

**Topic:** 8.10 Condition-Based Maintenance

**Subtopic:** 8.10.2T Ambient-Powered Wireless Network Smart Sensors for Intelligent Manufacturing

**Title:** Ambient-Power Wireless Network Smart Sensors for Intelligent Manufacturing

**NIST OU:** 820

**Firm:** Wilcoxon Research Inc.
 21 Firstfield Road
Gaithersburg, MD 20878-1703

**Principal Investigator:** Thurston Brooks
**Phone:** 301-216-3009

**Award Amount**: $73,515.00

**Abstract:** The objective of the research presented in this SBIR proposal is for the development of the component technology required for an ambient-powered (self-powered) sensor that communicates on a network and can be easily integrated into a manufacturing environment. Wilcoxon Research has extensive experience in the design, manufacturing, and customer support of vibration sensors and related equipment. This proposal would permit the company to explore a novel configuration for power sources that generate and/or scavenge power from the industrial environment. New packaging requirements and materials, along with a study for the extension of present concepts for a data acquisition system, are presented. Such a wireless system not only reduces the need for cabling, but also drastically lowers installation costs permitting more comprehensive instrumentation for the manufacturing operations.

**Commercial Applications:** The effective deployment of condition-based maintenance requires sensors that are low in cost, but also cost effective for installation. It is foreseen that wireless sensors will be used in collecting vibration data for processes where either the installed machines or their downtime is costly. Wilcoxon sees good opportunity to improve productivity and output quality of the $5B (annual) machine tool market.

**FY 2000 Phase I Award**

**Topic:** 8.11 Intelligent Control

**Subtopic:** 8.11.2T Simulation and Animation Tools Supporting RCS Control Systems Development

**Title:** Intelligent Software and Animation Tools for RCS Architecture Based Development

**NIST OU:** 820

**Firm:** Pathway Technologies, Inc.
510 Township Line Road
Blue Bell, PA 19422

**Principal Investigator:** Ananthakrishnan Suri
**Phone:** 610-941-7769

**Award Amount:** $75,000.00

**Abstract:** Based on the outline for a theory of intelligence, and using NIST's hierarchical real-time control system (RCS) architecture, we will develop **OpenSim** and **OpenAnimation** toolboxes consisting of the following innovations, namely, (i) Simulation and Animation Software Design that will seamlessly interface with RCS Hierarchy, (ii) Knowledge hierarchy consistent with the **four key paradigms** and **four key elements** of the theory of intelligence, (iii) Identification of an extensive collection of simulation models and algorithms that will lead to implementation level software for the knowledge hierarchy, (iv) Real-time Simulation that reduces computational load through efficient numerical algorithms, intelligent dynamic modeling, and real time planning, (v) Structured Approach to GUI and Animation Development. In Phase 1, we will provide detailed architecture of the S&A software design process, knowledge hierarchy based on theory of intelligence, extensive simulation models for Phase 2 software development, and real-time simulation environment employing our innovations. In Phase 2 we will incorporate the software algorithms into the ***OpenSim*** and ***OpenAnimation*** toolboxes so that they will seamlessly integrate with the RCS software libraries, thus resulting in a stand alone software product.

**Commercial Applications:** These toolboxes will be well suited for real-time simulation and hardware-in-the-loop simulation using commercial vendor boards such as dSpace, RTI, VxWorks. Our tools, because of its modular approach and rich API interfaces can provide an easy means of developing real-time interface to these types of boards and other vendor software. Secondly, our shell approach will allow one to incorporate only necessary features in the real-time environment. Thirdly, currently DSP boards are programmable using high level languages and hence custom API interfaces can be developed rapidly. We believe that our innovations will lead to a unique real-time environment for real-time testing of large-scale dynamic systems. The software as well as hardware interfaces will be open, modular, and hierarchical.

**FY 2000 Phase I Award**

**Topic:** 8.11 Intelligent Control

**Subtopic:** 8.11.6T Constitutive Equations for Lightweight Sheet Metal Forming

**Title:** Micromechanics and Constitutive Model Characterization for Sheet Metal Forming

**NIST OU**: 850

**Firm:** Northwest Numerics and Modeling, Inc.
150 Nickerson Street Suite 102
Seattle, WA 98109

**Principal Investigator**: Ronald Foerch
**Phone:** 206-352-8030

**Award Amount:** $74,704.43

**Abstract:** The next generation of higher efficiency vehicles will utilize lightweight materials to reduce the amount of power required for equivalent performance. The proposed project addresses engineering needs for this advancement by forming the basis of improved structural simulation methods in aluminum sheet metal forming. Application of modern state variable constitutive equations incorporating anisotropic effects in the yield shape and translation will be characterized to aluminum in more than one microstructural configuration. An anisotropic plasticity/viscoplasticity model with kinematic hardening, and a polycrystal model with slip-system hardening, intergranular hardening, and crystal lattice rotations will be used together. Finite strain validation is also emphasized in the project, using an integrated corotational formulation to maintain a consistent material referential where all the state variables exist, and the constitutive equations are evaluated. Innovative non-proportional biaxial sheer-extension testing at finite strain will be carried out to validate the strain measure of the corotational formulation, and investigate the models ability to accurately predict complex deformation histories. Microstructural investigation of the deformed test specimens will help define physically based coefficients and state variables (e.g. grain size and orientation, slip density, sub-grain) which can be introduced during Stage II developments. The combination of microstructural input variables, and the complexity of deformation paths in the biaxial tests will allow more thorough characterization for these materials than previously available.

**Commercial Applications:** The constitutive modeling capability proposed in this project is important for the DoC and Partnership for the Next Generation of Vehicles program because it will reduce costs by replacing expensive tests with high quality computer simulation, and provide the basis for more accurate design prediction in forming. Constitutive model advancements will lead to easier and more concrete characterization of materials for structural simulation with increased levels of confidence. The fundamentals used here are applicable to essentially all types of metal deformation, giving the project large commercial scope in different industries.

**FY 2000 Phase I Award**

**Topic**: 8.11 Intelligent Control

**Subtopic:** 8.11.07T Software for Weld Sensing and Control

**Title:** Software for Weld Sensing and Control

**NIST OU:** 850

**Firm:** IMPACT Engineering, Inc.
500 E. Biddle Street
Jackson, MI 49203

**Principal Investigator:** Stephen Ivkovich
**Phone:** 517-789-0098

**Award Amount:** $75,000.00

**Abstract:** *"The integrity of welded joints is a primary concern in the fabrication and repair of engineering structures. Rising expectations of system safety and longevity can only be met with improved production techniques ... Yet, recent improvements in automated welding equipment have not been accompanied by a corresponding increase in intelligent control systems."* Weld quality monitoring systems offer the opportunity to significantly improve the quality of welding applications in the manufacturing industry, insuring increasing process control and repeated quality in welded components. Yet, two primary factors are limiting the acceptance of this technology: ease of set-up for specific applications, and usefulness of system information outputs. The technology developed in this Phase 1 and follow-on Phase 2 will infuse simplicity, ease of set-up and automated "expert system" diagnostics into weld monitoring systems, accelerating the acceptance of this technology in the welding industry. The feasibility of this approach is demonstrated in three focused Phase 1 tasks: develop and demonstrate an effective framework and Human-Machine Interface (HMI) for automated adaptive learning and system set-up; develop and demonstrate an effective paradigm for advanced 'expert system' and automated diagnostics techniques; and demonstrate a factory-floor beta-test system as a foundation for Phase 2.

**Commercial Applications:** Weld monitoring and process control systems in all segments of the welding industry. Suitable for robotic, fixed automation and semi-automated applications.

**FY 2000 Phase I Award**

**Topic:** 8.11 Intelligent Control

**Subtopic:** 8.11.8T X-Ray Optics for Spectrometers in X-Ray Microanalytical Systems

**Title:** Improve X-ray Microanalysis in Environmental Scanning Electron Microscope Systems by Using Monolithic Polycapillary X-ray Optics

**NIST OU:** 830

**Firm:** X-Ray Optical Systems, Inc.
30 Corporate Circle
Albany, NY 12203-5719

**Principal Investigator:** Dr. Ning Gao
**Phone**: 518-464-3334

**Award Amount:** $74,948.00

**Abstract:** This SBIR Phase 1 project will determine the feasibility of greatly improving the spatial resolution and detection sensitivity of the energy dispersive x-ray (EDX) spectrometer in environmental scanning electron microscope (ESEM) systems by using monolithic polycapillary x-ray optics. An inevitable consequence of the presence of the gas in the sample chamber of an ESEM is the electron beam broadening due to scattering in the gas. The severely degraded spatial resolution has a large impact on x-ray microanalysis because the fluorescent characteristic x rays from the material out of the region of interest may overlap or interfere with the useful signals. We propose using a monolithic polycapillary x-ray optic as a spatial-filter to restrict the effective viewing area of the EDX spectrometer. The optic can collect a large solid angle of x rays from a small area (25-200 mm in diameter) at the center of the electron probe on the specimen and redirect them to the spectrometer. The success of the program will result in significantly improved x-ray detection sensitivity and spatial resolution, which are vital for electron-probe x-ray microanalysis in the ESEM. The proposing team, consisting of the world leaders in polycapillary optics and experts in ESEM and x-ray microanalysis, will ensure that the system will be rapidly commercialized once successfully demonstrated.

**Commercial Applications:** The addition of a polycapillary optic between the sample and the detector has commercial applications for a focused beam analytical system applied to advanced microanalytical problems including materials, semiconductor devices and environmental applications. The immediate commercial application to be pursued by XOS and NORAN Instruments (EDS supplier) is the addition of a polycapillary optic to the EDS detector in ESEM and LVSEM systems.

**FY 2000 Phase I Award**

**Topic:** 8.13 Infrastructure for Distributed Electronic Commerce

**Subtopic:** 8.13.3T Infrastructure for Interoperable MPI (IMPI) Parallel Algorithms

**Title:** Collective, Performance-Oriented Algorithms for Interoperable MPI

**NIST OU:** 890

**Firm:** MPI Software Technology, Inc.
101 S. Lafayette Street #33
Starkville, MS 39759-2946

**Principal Investigator:** Rosen Dimitrov
**Phone:** 662-320-4300

**Award Amount:** $75,000.00

**Abstract:** This Phase 1 SBIR Project will provide optimization framework and technology for interoperable Message Passing Interface Technology, and the underlying Message Passing Interface Standard. This effort represents a challenge and opportunity. With the emergence of cluster computing, there are many opportunities to connect diverse parallel programming environments based on the MPI programming model; currently interoperation is almost non-existent between such environments. The IMPI standard by itself addresses basic interoperability, and the results of this effort will drive performance of collective communication higher, in order to promote wider use of interoperable MPI for demanding performance situations. Interestingly, the practical support for high performance interoperable MPI's, and collective operations places important technical constraints on the underlying MPI implementations, including the ability to handle multiple network protocol stacks efficiently (called "devices" in MPI nomenclature). Proposer's underlying technology is particularly suited to adaptation to this task, more so than are public-domain implementations of MPI.

This effort will lead to wider use of interoperable parallel programming environments through the IMPI standard, and will widen the space of potential applications of IMPI-oriented parallel programming to additional commercially valuable applications, which need support for such heterogeneity. Proposer will commercialize the technology devised here through incorporation into MPI products.

**Commercial Applications:** Proposer already conducts its primary business activities in the area of parallel processing message passing software with Government, university and commercial clients in the United States and overseas. The added capability of the IMPI-tuner described in this proposal would provide competitive advantage for situations where customers want to interoperate several parallel machines or clusters, and demand high performance, which is becoming an increasingly high demand for commercial and research uses of parallel clusters and parallel machines.

**FY 2000 Phase I Award**

**Topic:** 8.13 Infrastructure for Distributed Electronic Commerce

**Subtopic:** 8.13.6T Mathematics on the World Wide Web

**Title:** Structural Analysis and Conversion of Mathematical Expressions

**NIST OU:** 890

**Firm:** MathSoft, Inc.
1700 Westlake Avenue N. Suite 500
Seattle, WA 98109-3044

**Principal Investigator:** Jisheng Liang
**Phone:** 206-283-8802

**Award Amount:** $74,998.00

**Abstract:** Scientific community is making increasing use of the World Wide Web to exchange scientific documents and deliver scientific reference data to the public. Much of this data has significant mathematical content, such as limits, integrals, differential equations, matrices, etc. Current technology for representing and displaying such content in document format, such as HTML, PDF/Post Script, and TeX/LaTeX, is both primitive and inefficient. New and emerging standards, such as XML, MathML, and OpenMath, promise to greatly improve this situation. Mathematical equations in electronic form can be input to computer algebra tools, such as Mathcad, Matlab and Mathematica, which can decode the equation and do the computation automatically. The goal of this research is to develop stable and robust production-quality tools to convert existing mathematical content to new standards, and to correctly convert the resulting mathematical expressions into the internal format of mathematical computation systems. During the Phase 1, we will concentrate on the structural analysis of math expressions and will implement a tool to convert LaTeX encoded mathematical expressions to MathML/OpenMath.

**Commercial Applications:** The potential applications of the proposed system include: exchange of scientific/mathematical documents on the Web; cut and paste of equations in various formats to a computer algebra system, such as Mathcad from MathSoft, and vise versa; conversion and interpretation of a large collection of technical documents for the creation of a database; and reading machine for the visually impaired.

**FY 2000 Phase I Award**

**Topic:** 8.13 Infrastructure for Distributed Electronic Commerce

**Subtopic:** 8.13.7T Application-Based Intrusion Detection Techniques

**Title:** Using Cluster Analysis to Detect Attacks Against Database Management Systems

**NIST OU:** 890

**Firm:** Stottler Henke Associates, Inc.
1660 So. Amphlett Boulevard Suite 350
San Mateo, CA 94402

**Principal Investigator:** Terrance Goan
**Phone:** 206-545-1478

**Award Amount:** $75,000.00

**Abstract:** We propose an innovative machine learning approach to detecting anomalous and intrusive Database Management System (DBMS) usage. By drawing on our experience developing knowledge discovery and intrusion detection systems, we have devised a unique clustering-based approach to formulating data characterization models that can be used as the basis for detecting the misuse of data resources. By recognizing the deeper structure of monitored usage patterns and databases, our CASAD (Clustering Activity Streams for Anomaly Detection) system will be capable of accurately recognizing unique classes of database transactions and user behavior. Our approach recognizes the fact that identifying suspicious DBMS use will involve analyzing high-dimensionality data that may include ordered sequences of operations or data transformations. Further, unlike other clustering techniques, our approach will allow 'seeding' with user provided knowledge (e.g., constraints on acceptable data transitions) and be capable of effectively using feedback to improve its characterization of data and use patterns. This capability will make CASAD uniquely competent in database anomaly and misuse detection. The Phase 1 development of a proof-of-concept prototype will demonstrate the feasibility of our approach.

**Commercial Applications:** Our approach to data characterization and intrusion detection will be applicable across a very large spectrum of database systems including those utilized by an ever-growing population of electronic commerce companies.

**FY 2000 Phase I Award**

**Topic:** 8.13 Infrastructure for Distributed Electronic Commerce

**Subtopic:** 8.13.9T XML for Workflow Management

**Title:** A Tool Kit for Creating Web-based Workflow Applications using XML and CORBA

**NIST OU:** 820

**Firm:** Dokken Software, Incorporated
100 North 27th Street Suite 250
Billings, MT 59101

**Principal Investigator:** Jason Dokken
**Phone:** 406-256-8300

**Award Amount:** $75,000.00

**Abstract:** Today's workflow technology suffers from a lack of software tools that facilitate application development and open data exchange for businesses operating on the Web. We propose to address those weaknesses by creating a tool kit for building Web-based workflow applications. The tool kit will employ the unique combination of XML (eXtensible Markup Language) for data representation and CORBA (Common Object Request Broker Architecture) for asynchronous, bi-directional communication between client and server. By combining the strengths of XML and CORBA, the tool kit will enable Web-based workflow applications that are superior to those found today.

The objectives of this proposal include showing feasibility of passing XML-based user interface constructs, data presentation constructs, and data between client and server. The proof for this work will be shown via an on-line demonstration where a remote user--using only a browser--will complete a workflow process. Exploiting the flexibility of the XML/CORBA combination will help Dokken Software Incorporated (DSI) create a market-ready tool kit. The 1999 market for Web-based workflow has been estimated at over $3 billion. DSI plans to enter that market by building a software product line around the tool kit following Phase 2 of this work.

**Commercial Applications:** Distributed banking, securities trading, finance, engineering, manufacturing, health care, insurance, accounting, and human services; also local, state, and federal government agencies.

**FY 2000 Phase I Award**

**Topic**: 8.14 Measurement and Standards for Composite Materials

**Subtopic:** 8.14.1T Nondestructive Evaluation of Microstructure in Graphite/Glass Hybrid Composites

**Title:** Nondestructive Evaluation of Microstructure in Graphite/Glass Hybrid Composites

**NIST OU:** 850

**Firm:** Texas Research Institute Austin, Inc.
9063 Bee Caves Road
Austin, TX 78733-6201

**Principal Investigator:** Russell Austin
**Phone**: 512-263-2101

**Award Amount:** $75,000.00

**Abstract:** Fiber Reinforced Plastic (FRP) composite offer weight and corrosion advantages for civil applications when structural needs can be met cost effectively. New "hybrid" FRP materials provide large increases in mechanical properties with nominal cost increase by placing a limited amount of high-strength, expensive graphite fibers in highly stressed regions of otherwise glass fiber reinforced composites. This benefit can only be realized by measuring the exact content, orientation, and location of both types of fibers.

Nondestructive evaluation (NDE) methods are available for measuring fiber structure, as well as general flow detection. However, these NDE techniques were developed for FRP materials with only one type of fiber. Research has been done to apply these methods to hybrids, but a direct comparison has never been conducted.

TRI/Austin will identify, and demonstrate feasibility of, NDE methods best suited to evaluate microstructure in hybrid composites. Tasks include a comprehensive information review; sample collection from hybrid composite manufacturers' round-robin laboratory testing by qualified NDE laboratories; and a non-biased evaluation of all findings. TRI/Austin, the home of NTIAC, routinely performs these types of projects.

Phase 1 lays the groundwork for developing testing procedures and calibration samples, allowing manufacturers and end users to confidently certify hybrid components.

**Commercial Applications:** Design, manufacture and in-serve inspection of composite versions of: bridge members, pilings, fenders, offshore pipe cradles, offshore oil platform secondary structural members, offshore storm water drainage, petrochemical storage tanks, boat hulls, and vehicle (railcar, bus, truck) bodies.

**FY 2000 Phase I Award**

**Topic**: 8.16 Microelectronics Manufacturing Infrastructure

**Subtopic:** 8.16.1T Co-axial Atomic Force Microscope Probes for Electrical Measurements

**Title:** Co-Axial AFM Probes for Near-Field Microwave and Electrical Measurements

**NIST OU:** 810

**Firm:** Manufacturing Instrumentation Consultant Company
2762 Berkshire Road
Cleveland Hts., OH 44106

**Principal Investigator:** Natal Rodrigo
**Phone:** 216-368-6431

**Award Amount:** $74,610.90

**Abstract:** We propose to design and fabricate co-axial electromagnetically shielded scanning microwave probes compatible with atomic force microscopy with very sharp tips (<50 curvature, 10-15 m high) and suitable for near-field microwave scanning of materials in the 1-20 GHz range. Our proposed co-axial probes have an outer metallic ground layer for better shielding at high frequencies due to its smaller skin depth. The inner probe tip consists of an oxidation sharpened silicon tip with very high doping concentration for good conductivity. An oxide layer is used as the insulator. The signal is connected to these tips using a gold co-planar waveguide. Co-planar weveguides can be probed easily and they also provide superior frequency characteristics and isolation between parallel probes. MICC has extensive experience with near-field microwave probes, high frequency instrumentation and measurements and microfabrication techniques.

**Commercial Applications:** The proposed scanning microwave probes have many applications in the semiconductor industries as real-time in-situ nondestructive measurement system for quality assessment and intelligent manufacturing. The commercial market for the SMM as a manufacturing quality assurance tool is around 1B/year in the US alone. It has many other applications in bio and agricultural materials. MICC is working on all these other applications as well.

**FY 2000 Phase I Award**

**Topic:** 8.16 Microelectronics Manufacturing Infrastructure

**Subtopic:** 8.16.2T In-Situ, Closed Loop Control of Semiconductor Epitaxial Deposition

**Title:** In-Situ X-ray Characterization for Real-time Monitoring and Closed-Loop Control of the Epitaxy of III-V Heterostructures

**NIST OU:** 810

**Firm:** Epitaxial Technologies, LLC
1450 South Rolling Road
Baltimore, MD 21227

**Principal Investigator:** Dr. Olaleye Aina
Phone: 410-455-5594

**Award Amount:** $73,846.00

**Abstract:** Epitaxial Technologies proposes to develop novel in-situ characterization tools and closed-loop control algorithms that will enable precision MBE growth of advanced III-V materials. We will achieve this objective through system reconfiguration and by devising appropriate measurement metrologies to use in-situ x-ray characterization to monitor layer thicknesses and compositions which can then be combined algorithmically with other MBE system sensor data to achieve closed-loop control.

The primary goal of this proposed Phase 1 effort is to demonstrate the feasibility of these novel approaches by performing a system reconfiguration study and by initiating preliminary in-situ characterization investigations. In Phase 2, the MBE system reconfiguration will be further refined, the in-situ x-ray characterization system will be completed and incorporated into a new production MBE system for complete validation. A concurrently developed in-situ x-ray characterization tool will be delivered to NIST.

**Commercial Applications:** This project will result in an in-situ x-ray diffraction characterization system which can be attached to MBE systems and used for in-situ growth condition monitoring and material characterization. It will also enable high yield MBE wafer production thus lowering the cost of epitaxial wafers and circuit chips fabricated with them. The proposed in-situ x-ray characterization tool will also be applicable in material deposition systems such as thermal and electron beam evaporators, sputtering systems and vapor phase deposition systems.

**FY 2000 Phase I Award**

**Topic:** 8.16 Microelectronics Manufacturing Infrastructure

**Subtopic:** 8.16.6T Measurement of Trace Alpha Radiation in Polymenric Microchip Material

**Title:** Alpha Detector with Active Background Suppression for Electronic Materials Characterization

**NIST OU:** 810

**Firm:** X-ray Instrumentation Associates
8450 Central Avenue
Newark, CA 94560-3430

**Principal Investigator:** Dr. John Wahl
**Phone:** 510-494-9020

**Award Amount:** $75,000.00

**Abstract:** As flip-chip bonding becomes the predominant standard in the electronics industry, the increased proximity between dice surfaces and packaging materials will require a significant reduction in the latter's alpha particle activity in order to avoid soft errors. emission rates approaching 0.0001 /cm2/hr are desirable, which is well below the 0.0050 /cm2/hr capability of today's best detectors. We propose to address this need by developing an active background suppression scheme to dramatically improve the performance of a gas-filled wire chamber. In this scheme we will digitize signals from the detector and apply pulse shape analysis to identify their point of origin within the detector and reject those that do not come from the sample. In preliminary work, we have already obtained 0.0200 /cm2/hr on a crude handbuilt detector. In Phase 1 we propose to demonstrate the feasibility of attaining 0.0001 /cm2/hr and, in Phase 2, to construct a working commercial prototype.

**Commercial Applications:** The initial commercial application will be a detector for screening polymeric and other packaging materials for the electronics industry at 0.0001 /cm2/hr activity levels. We will then work to replace the Si barrier detectors used for environmental and health physics screening applications since our background level will be over 100 smaller and our active area 100 or more times larger.

**FY 2000 Phase I Award**

**Topic:** 8.16 Microelectronics Manufacturing Infrastructure

**Subtopic:** 8.16.10T High Speed/Low Power Magnetic Field Sensing Devices

**Title:** High Speed/Low Power GMR/SDT Devices for Magnetic Field Sensing

**NIST OU**: 850

**Firm:** Nonvolatile Electronics, Inc.
11409 Valley View Road
Eden Prairie, MN 55344-3617

**Principal Investigator:** Dexin Wang
**Phone:** 612-996-1608

**Award Amount**: $74,893.00

**Abstract:** This SBIR Phase 1 program will demonstrate the feasibility of fabricating high-speed/low power magnetic field sensing devices by incorporating high-speed magnetic films into giant magnetoresistive (GMR) structures. In the last decade, the speed of logic gates has been driven into keep sub-nanosecond regime, yet the speed of magnetic devices is still limited to nanoseconds under moderate fields. Although higher speed magnetic switching can be achieved by higher magnetic field, it takes inproportionally high power to do so for conventional magnetic films used in all GMR and SDT structures. In contrast, high-speed magnetic films require less power to switch at the same fast speed in the GHz range. We propose to fabricate spin valve bridge devices using high-speed magnetic films with our proprietary push-and-pull approach, and make the bridges compatible with fast electronics. The end devices will have state of the art static properties, a switching speed higher than 1 GHz, and a reasonably low power budget (<1 mW with 1 V supply). In the Phase 2, we will also explore spin-dependent tunneling (SDT) devices, which have several technological advantages compared with GMR, including a higher output signal, lower power consumption and smaller size, and integrate these devices with electronics.

**Commercial Applications:** There are several applications for this research in high-speed magnetic field and current sensing devices, high-speed isolators, fast magnetic random access memories (MRAM), magnetic reconfigurable logic, and next generation read heads.

**FY 2000 Phase I Award**

**Topic:** 8.18 Photonics Manufacturing

**Subtopic:** 8.18.2T Actively Quenched IR Avalanche Photodiode

**Title**: Actively Quenched InGaAs:Si Fusion Bonded APD

**NIST OU:** 810

**Firm:** Voxtel, Inc.
 2604 SW Georgian Place
 Portland, OR 97201

**Principal Investigator:** James Gates
**Phone:** 503-224-8379

**Award Amount:** $75,000.00

**Abstract:** In this Phase 1 program, Voxtel proposes to demonstrate the feasibility of manufacturing a large area, high speed, actively quenched, NIR avalanche photodiode (APD) using the InGaAs: Si wafer fusion. In the absence of an intermediate layer, fusion bonding with elastic accommodation of the InGaAs: Si layers is accomplished by removing the InP substrate layer before any high temperature annealing.

Materials with high optical absorption coefficients and high speed, low noise amplification characteristics are required of large area, low dark current, fast, efficient APDs. In the near infrared, InGaAs is an excellent choice for an absorber. Because the electron ionization coefficient of silicon is 100 times larger than the hole ionization coefficient, it is an ideal avalanche material. Wafer fusion of the materials results in high gain bandwidth products by implementing very thin bulk gain regions or through band structure engineering using multiple quantum well gain regions.

The monolithic quenching circuit uses a novel current amplifier scheme to tract and quench the APD avalanche current and reset more quickly.

During the Phase 1 program, Voxtel will perform Taguchi experiments to optimize the device design and processes. An active quenching circuit will be designed, manufactured, and tested and a monolithic device will be designed for the subsequent Phase 2 program.

**Commercial Applications:** New instruments for astrophysics, astronomy, planetary exploration, earth observation, spectroscopy, telecommunications, night vision, and biomedical applications in the NIR.

**FY 2000 Phase I Award**

**Topic:** 8.19 Supporting Technologies for Semiconductor Lithography

**Subtopic:** 8.19.1T Detectors for Deep Ultraviolet Excimer Laser Photolithography Dose Metrology

**Title:** Degradation Resistant and Incident Angle Insensitive Pyroelectric Detectors for Deep Ultraviolet Dose Metrology

**NIST OU:** 810

**Firm:** Molectron Detector Inc.
7470 SW Bridgeport Road
Portland, OR 97224-7286

**Principal Investigator:** Dr. James Schloss
**Phone:** 503-603-9749

**Award Amount:** $75,000.00

**Abstract:** The development of highly accurate dose sensors for 157 nm photolithography is of critical importance for the proper operation of F2 excimer laser stepper systems. Pyroelectric detectors best fit the performance requiremnts for a 157 nm dose sensor. The technical challenges for pyroelectric detectors applied to 157 nm photolithography are degradation of the DUV absorbing layer and poor angular response. A novel ceramic coating process which is compatible with pyroelectric detector processing is proposed as a solution to the material degradation issue. This coating procedure has a low capital investment and can produce a wide range of ceramic materials. A second benefit of this ceramic coating is that its inherent surface roughness leads to improved angular response.

**Commercial Applications:**
Dose sensors for deep ultrviolet excimer laser based stepper systems in photolithography.
Laser power and energy sensors for output control and monitoring of deep ultraviolet laser systems.
Laser power and energy sensors for deep ultraviolet laser micromachining systems.

**FY 2000 Phase I Award**

**Topic:** 8.20 Integration of Manufacturing Applications

**Subtopic**: 8.20.3T Ontological Engineering Applied to Manufacturing System Integration Research

**Title:** Broadening Effective Participation in Distributed Collaborative Ontology Development

**NIST OU:** 820

**Firm:** Stottler Henke Associates, Inc.
1660 So. Amphlett Boulevard Suite 350
San Mateo, CA 94402

**Principal Investigator:** Eric Domeshek
**Phone:** 650-655-7242

**Award Amount:** $75,000.00

**Abstract:** As ever more of industry and commerce moves onto electronic networks, there is a growing appreciation for the usefulness of expressive general models of enterprise activities, such as design and manufacturing. Ontologies - as developed in the Artificial Intelligence (AI) Knowledge Representation and Sharing communities - are commitments to formal declarative multi-purpose representation with clear semantics that can serve as a solid foundation for such models. While there has been much work on representation languages, and on tools for creating, browsing, editing, and translating expressions in such languages, there has been relatively little attention to supporting the larger process of figuring out what ought to be encoded in an ontology. Existing tools, while built on aspects of Web infrastructure and offering some support for collaborative teams, by and large seem to assume that all team members will be AI experts and that all work will focus on the formal expressions that make up the final ontology. Within the scope of this project, we propose to develop an initial prototype of a Domain Expert Collaborative Ontology Development Environment (DECODE) that ensures those who best understand the domain, but least understand the technology of ontology, can make necessary contributions to the development process.

**Commercial Applications:** By enabling effective participation in the ontology development process by those who actually understand the target domain and will use the ontology, this technology will lower the cost and increase the quality of ontologies developed to integrate functions in a particular organization.

**FY 2000 Phase I Award**

**Topic:** 8.21 General

**Subtopic:** 8.21.3T Linear Magneto-Resistive Array for Imaging Data Storage Media

**Title:** High-Resolution GMR Sensor Array for Imaging Data Storage Media

**NIST OU:** 810

**Firm:** Nonvolatile Electronics, Inc.
11409 Valley View Road
Eden Prairie, MN 55344-3617

**Principal Investigator:** Dr. Carl Smith
**Phone:** 612-892-9217

**Award Amount**: $75,000.00

**Abstract:** This Small Business Innovation Research Phase 1 project will develop and demonstrate the sensor technology and electronics of a high-resolution GMR sensor array for imaging data storage media. The technical objectives include a sub array of 8 or 16 sensors which will resolve data on magnetic media with 5 m by 5 m resolution and a sample data rate of 16 kHz per sensor. The design work will include studying the feasibility of a full-scale 560 sensor array with the same resolution over a 2.8 mm width and with on-chip integrated electronics. A full-scale integrated GMR sensor array for imaging data storage media will be the objective of a Phase 2 extension.

**Commercial Applications:** The anticipated results of a successful Phase 1 and Phase 2 project will be a working, high-resolution integrated prototype sensor with 5 m by 5 m resolution and a 2.8 mm working width. This device could be directly taken in to production and marketed to the data recording industry. In addition, the integrated sensor array technology developed in Phase 1 and Phase 2 projects could be applied on a larger scale with lower resolution to a number of other markets including currency validation, nondestructive evaluation, biosensors, and magnetic domain imaging.

**FY 2000 Phase I Award**

**Topic:** 8.21 General

**Subtopic:** 8.21.8T Fast-Scanning FTIR Spectrometer for Measurements in Spray Flames

**Title:** A Fast-Scanning FT-IR Emission/Transmission Spectrometer for Spray Combustion Diagnostics

**NIST OU:** 810

**Firm:** Advanced Fuel Research, Inc.
87 Church Street
East Hartford, CT 06108-3742

**Principal Investigator:** Dr. David Marran
**Phone:** 860-528-9806

**Award Amount:** $74,906.00

**Abstract:** Advanced, non-intrusive combustion diagnostics for multiple gas species concentrations and temperature, soot volume fraction and temperature, as well as droplet characteristics (both size and number density) are needed to enhance our understanding of spray combustion systems. Although many of these combustion related properties can be measured using separate, specialized diagnostics, a single, simple to use method capable of measuring many of these parameters is desired. Fourier Transform Infrared Emission/Transmission (FT-IR E/T) Spectroscopy has been demonstrated to be a valuable and extremely versatile diagnostic capable of performing these measurements, but traditional FT-IR spectrometers are highly susceptible to temporal fluctuations in the measurement volume. These fluctuations, which can be caused by particle transit, turbulence, or other combustion instabilities, introduce significant noise into the measured spectrum, especially in the low wavenumber end. These effects are most problematic in spray combustion, where particle transit noise seriously degrades the signal-to-noise of the measured spectra. In order to minimize the effect of temporal fluctuations on the measured spectrum, a high speed FT-IR E/T spectrometer needs to be developed. This spectrometer will be combined with a novel Hadamard tomography scheme developed to provide spatially resolved information on gases, droplets, particles and soot in multiphase combustion systems.

**Commercial Applications:** The instrument to be developed through Phase 2 will have wide applicability as a research and development tool in many areas of combustion. The Phase 2 prototype product will be delivered and installed at the NIST spray combustion facility in Maryland. This first Government delivery will lead to a point of reference for other Government facilities and universities concerned with gas combustion and spray combustion diagnostics. Both the turbine engine industry and boiler industry are based on spray combustion. Considerable industry work is focused on spray nozzle/combustor design to minimize combustion instabilities and maximize efficiencies. The combustion industry would benefit from a diagnostic tool to expedite combustor development and the product of this DoC project will fill an important role in the industry. Another niche area, which is growing in importance, is the use of combustion processes to produce fine particles, such as the combustion of silica to product SiO2, and the combustion of TiC14 to produce TiO2. These are both large volume commodity chemicals. Minor improvements in process efficiency and quality can result in substantial manufacturing savings, thus making advanced diagnostics cost effective tools.

**FY 2000 Phase I Award**

**Topic:** 8.21 General

**Subtopic:** 8.21.10T Synthesis and Characterization of Semiconductor Nanocrystals: Standards for Fluorescence Intensity in Medical Devices and Medical Diagnostics

**Title:** Rational Design of Ligands for Stable, Biologically Accessible and Highly Luminescent Semiconductor Nanocrystals

**NIST OU:** 830

**Firm:** NanoSonic, Inc.
P.O. Box 618
Christiansburg, VA 24068

**Principal Investigator:** Dr. Yongqiang Wang
**Phone:** 540-953-1785

**Award Amount:** $74,999.00

**Abstract:** This program aims to solve the linking chemistry problem of highly luminescent semiconductor nanocrystals used for medical devices and medical diagnostics. NanoSonic's proposed strategy is, by the polymerization of surface-capping ligands, to convert an inorganic nanocrystal to a chemical entity acting like a spherical organic or biological macromolecule. This will enable the enormous amount of existing knowledge about linking chemistry for organic and biological macromolecules to be readily applied to the linkage of these types of semiconductor nanocrystals and biological targets. Additionally, the polymerization of the surface ligands enhances the stability of the semiconductor nanocrystals to the level of an ordinary organic macromolecule**.** We will rationally design and synthesize a series of organic ligands with the polymerizable group in the middle of the two polar terminal groups. One of the terminal groups will bind readily to the surface of highly luminescence semiconductor nanocrystals. The other terminal group of the ligand will make the nanocrystals soluble in water and provide the linking site for the biological targets. The ultimate goal of the Phase 1 program is to discover one or two ligands that meet the desired properties of the nanocrystal-ligand combination for the biological analysis applications described in the proposal.

**Commercial Applications:** Fluorescence-based analytical techniques have wide applications in biology, chemistry and physics. Once the core technical problems of semiconductor nanocrystals as fluorophores are solved in Phase 1, the large-scale synthesis of these commercially important nanocrystals will be quickly developed in Phase 2.

**FY 2000 Phase I Award**

**Topic:** 8.21 General

**Subtopic:** 8.21.11T The Development of Critical Renewable Validation Materials for Molecular Diagnosis

**Title:** Controls for Cystic Fibrosis Mutation Detection Assays

**NIST OU:** 830

**Firm:** Maine Molecular Quality Controls, Inc.
125 John Roberts Road
South Portland, ME 04106

**Principal Investigator:** Clark Rundell
**Phone:** 207-842-7916

**Award Amount:** $75,000.00

**Abstract:** The rapid rate at which disease-causing genes are being discovered has elicited an explosion of genetic diagnostic technologies. Because development of molecular validation materials has not kept pace, available controls, chiefly patient-based materials, often do not represent the variety of mutations being detected. We propose to engineer a synthetic construct that will serve as a model for reference material useful for quality assurance of multiple detection assays. In Phase 1 we will ligate two exons of the cystic fibrosis transmembrane conductance regulator (CFTR) gene, and subsequently introduce the most prevalent cystic fibrosis (CF) mutation, deltaF508. In a similar construct, we will introduce the deltaI507 mutation, sometimes misidentified as deltaF508 in current assays. Successful constructs will demonstrate a ligation scheme that facilitates removal of any exon so that it may be mutated and then re-ligated. In Phase 2 we will produce constructs comprised of all 27 exons of the CFTR gene, including intronic borders. Using our cassette design, a variety of mutations will be introduced to produce a series of controls appropriate for current CF testing menus. Our project will play a key role in establishing a system to provide quality assurance material for genetic diagnostic tests.

**Commercial Applications:** Controls for most genetic diagnostic tests, particularly those used to detect multiple mutations, are currently unavailable. Clinical laboratories require controls for every patient-testing event and researchers need reference materials to validate their results. Manufacturers require reference materials as they develop new technologies, as do regulatory agencies responsible for ensuring accurate patient test results. The proposed system of synthetic constructs will make available cost effective materials for use as controls in cystic fibrosis mutation detection.

**FY 2000 Phase I Award**

**Topic:** 8.21 General

**Subtopic:** 8.21.13T Development of a "Turn-Key", Broadly Tunable Source for Terahertz Spectroscopy Applications

**Title:** Turn-Key, Broadly Tunable, THz Source

**NIST OU:** 840

**Firm:** DeMaria ElectroOptics Systems, Inc.
1280 Blue Hills Avenue
Bloomfield, CT 06002-1301

**Principal Investigator:** Dr. Eric Mueller
**Phone:** 860-243-9557

**Award Amount:** $74,963.32

**Abstract:** A turn-key, broadly tunable, THz source is proposed here. This source utilizes DEOS's high-reliability THz space laser technology combined with an ultra-high frequency Scotch diode and millimeter-wave source, to yield a reliable, tunable, THz source. The applications for such a source are numerous and include: characterization of semiconductor materials and devices, characterization of composites, characterization of plastics, monitoring of plastics curing, remote sensing, and trace chemical detection. The development of this technology will complement DEOS's existing THz laser products, placing DEOS in a unique competitive position.

**Commercial Applications:**
Characterization of semiconductors and semiconductor Devices
Characterization of composite
Characterization of plastics
Monitoring of plastics curing
Remote sensing
Trace chemical detection

**FY 2000 Phase I Award**

**Topic:** 8.21 General

**Subtopic:** 8.21.18T Modeling of Optical Radiometric Calibration System

**Title:** Internet-accessed Calibration System Analysis Toolkit

**NIST OU:** 840

**Firm:** Frontier Technology, Inc.
6785 Hollister Avenue
Goleta, CA 93117

**Principal Investigator:** Thomas Murdock
**Phone:** 978-927-4774

**Award Amount:** $74,994.00

**Abstract:** This proposal addresses the need for radiometric calibration system modeling tools that are approved and certified by the National Institute of Standards and Technology (NIST). FTI offers to create for NIST an Internet-accesses Calibration System design and performance Analysis Toolkit (CSAT). A NIST-approved Internet accessible modeling tool which incorporates NIST-traceability standards and NIST recommended practices would have a great potential to facilitate traceability of the calibration to the International System of Units and allow cross-calibration among different sensors that are used in community-wide or shared scientific analysis. The scope of the proposed effort is to incorporate NIST-traceable source and NIST-certifiable optical system level models and performance modeling tools into an expert system that will be accessed and executed by users over the Internet from the Internet Browser on their computer. Our innovative web-enabled approach will allow the users to access these codes for a reasonable cost. Small-company type users might not otherwise be able to have the advantage of such computational power because of cost or hardware limitations.

**Commercial Applications:** A major goal of the Phase 1 effort is an initial identification of potential commercialization opportunities, including both governmental and non-governmental end-user customers. It is envisioned that ground based and on-orbit remote sensing applications would benefit with the use of this modeling tool. It is envisioned that agricultural, environmental, industrial, law enforcement and military applications would be enhanced by the use of such a tool.

**FY 2000 Phase I Award**

**Topic:** 8.21 General

**Subtopic:** 8.21.22T Ultra High Efficiency Solid State Soft X-Ray Detectors for Low Z Fluorescence

**Title:** X-Ray Detectors for Low -Z Fluorescence Measurements

**NIST OU:** 850

**Firm:** Physical Sciences, Inc.
20 New England Business Center
Andover, MA 01810-1077

**Principal Investigator:** Willi Schwarz
**Phone:** 703-941-0495

**Award Amount:** $74,934.00

**Abstract:** The goal of the proposed program is to develop detectors for X-ray fluorescence that have enhanced efficiency and energy resolution for low energy (1 keV) X-rays. The better performance will be achieved through (1) determination of a process to reduce the "dead layer" in the crystal that, in existing detectors, limits the penetration of low energy X-rays into the active semiconductor material, and (2) realization of a process for depositing the window isolating the detector from the environment directly on the crystal. Both Si(Li) and high purity germanium (HPGe) detectors will be addressed. As part of the program, models forquantifying dead layers depths in and for predicting the spectrum characteristics of HPGe and Si(Li) X-ray detectors will be developed and used for detector optimization. The final goal of the program is a detector with anIncomplete Charge Collection(ICC) ratio of less than 0.6%.

**Commercial Applications:** (1) applications utilizing energy dispersive X-ray micro analysis with scanning and transmission electron microscopes, (2) industrial applications using X-ray tube fluorescence, (e.g.,quality control of semiconductor wafer fabrication), and (3) fundamental materials research by fluorescing samples from a monochromatic synchrotron beam.

**FY 2000 Phase II Award**

**Topic:** Adaptive Learning Systems

**Subtopic:** 8.6.1T

**Title:** Adaptive Learning in Web-Based Instructional Systems

**NIST OU:** 820

**Firm:** Intelligent Systems Technology, Inc.
2800 28th Street Suite 306
Santa Monica, CA 90405

**Principal Investigator**: Dr. Azad Madni
**Phone:** 310-581-5440

**Award Amount:** $299,877.91

**Abstract:** The overall objective of this SBIR effort is to design, develop, demonstrate, and commercialize a prototype web-based adaptive instructional system. In Phase 1I, we created the system concept and technical architecture for this system and review candidate applications to demonstrate the technology. The key innovations that resulted from the Phase 1 R&D are: (a) a scaleable, customizable, adaptive instruction framework integrated with knowledge management facilities for knowledge sharing and reuse; (b) a formal learning-instruction ontology that supports the extensibility and customizability of the instructional system; and (c) prototype GUI screens for template-based course authoring and personalized, web-based training. Phase 2I will implement and demonstrate the overall capability of the concept prototype on an application of interest to NIST and the commercial sector.

**Commercial Applications:** Commercial applications of this research include: web-based, 7x24 learning in: (a) preparing for packaged application installation (e.g., ERP, CRM); (b) reinventing processes to Internet-enable an organization; (c) methods for accelerating clinical trials in genome research; and (d) planning new corporate initiatives such as business expansion, ISO certification planning and support, and obtaining FDA product approval.

**FY2000 Phase II Award**

**Topic**: Advanced Building Materials and Systems

**Subtopic:** 8.7.5T

**Title**: High Temperature Thermal Conductivity Apparatus

**NIST OU:** 860

**Firm:** MetSys Corporation
P.O. Box 317 2014 Millwood Road
Millwood, VA 22646

**Principal Investigator:** Daniel Flynn
**Phone:** 540-837-2186

**Award Amount:** $300,000.00

**Abstract:** It is proposed to develop an advanced-design guarded hot plate apparatus that will define the new state of the art for measuring the thermal conductivity of thermal insulation materials over the temperature range from 90 to 900 K. The initial apparatus to be developed under this Phase 2 project, to be used by NIST, will have the capability to carry out measurements under controlled environments of air, a selected gas, or vacuum. The specific technical objectives of the Phase 2 development effort include: establish a task completion schedule; develop additional numerical models of the thermal performance of various components of the apparatus; carry out further reviews of material property data and fabrication techniques; analyze alternative approaches to the most crucial design features of the apparatus; develop a detailed design of the complete apparatus; prepare a set of recommendations for the measurement and control instrumentation; develop software and analysis procedures for operation of the plate apparatus and estimation of measurement uncertainties; oversee the fabrication of the guarded hot plate apparatus; prepare a detailed plan for initial testing and performance verification of the completed apparatus, including determination of measurement uncertainties, and oversee that testing and performance verification; write papers describing the work done during this project; develop one or more designs for commercial versions of the new NIST guarded hot plate apparatus and seek non-government funding or collaborations with other companies in order to enable commercial development and rapid entry into the marketplace; and prepare a final report documenting the Phase 2 developments in detail.

**Commercial Applications:** It has been estimated that over 1.4 quadrillion Btu's could be saved each year if industry installed economically optimal insulation.The guarded hot plate apparatus to be developed for NIST under this project will provide the U.S. with an unparalleled capability to provide accurate thermal conductivity data, either for future reference materials or for critical thermal insulations, to manufacturers and users of industrial thermal insulations for a wide variety of applications, thus allowing selection and installation of greatly improved insulation systems.

**FY2000 Phase II Award**

**Topic:** Intelligent Control

**Subtopic:** 8.11.7T

**Title:** Optical Coherence Tomography Based Fiber Optic Sensor for Monitoring and Control of Composites Processing

**NIST OU:** 850

**Firm:** Optiphase, Inc.
7652 Haskell Avenue
Van Nuys, CA 91406

**Principal Investigator:** Jeff Bush
**Phone:** 818-782-0997

**Award Amount:** $298,977.00

**Abstract:** An optical coherence tomograph (OCT) based fiber optic sensor can provide non-invasive, high resolution, monitoring for control of composites processing in commercial manufacturing. OCT is a non-contact optical technique for imaging in scattering media such as glass reinforced composites. With <30 micron resolution achieved by OCT, microstructure and defects such as: fiber wetting, void structure, fiber orientation, fiber waviness, cracks and delaminations of composites can be determined. To commercialize this technology, a compact, robust, portable, and inexpensive OCT system must be designed and built which is insensitive to birefrigence artifacts observed in typical OCT systems. Optiphase, Inc. proposes to develop an innovative, all fiber optics OCT system utilizing a unique piezoelectric fiber optic modulator and a polarization sensitive design. Polarization sensitivity eliminates birefringence shadowing and artifacts and provides material strain information. The all fiber optic design provides compactness, ruggedness, portability and cost savings over bulk optic or hybrid systems. The project objectives are to design, test, and build a prototype all fiber optic OCT system and then use this system for monitoring composite processing in an industrial setting.

**Commercial Applications:** The ruggedness, compactness, low cost, and non-invasive nature of an all fiber optic OCT system make this sensor applicable to monitoring, control, and automation of manufacturing processes and health monitoring of composites. In particular, an all fiber optic OCT sensor will be instrumental in monitoring microstructures during mold filling, predicting permeability for modeling of Liquid Composite Molding (LCM), and detecting damage such as cracks and delaminations of parts in the field. All these applications are especially pertinent to the automotive and marine composite industries. Additional commercial applications exist in the medical field as a diagnostic tool for imaging of biological tissue such as the human retina, skin, blood vessels, and tooth and gums. Optiphase, Inc. has already placed over 30 all fiber optic OCT modules with researchers at various companies and institutions pursuing OCT applications. These applications include: imaging of tooth enamel for detection of carries, imaging of oral gum lines to measure the severity of gingivitis, material property measurements of paints and pharmaceutical coatings and thickness measurement of thin films in production environments.

**FY2000 Phase II Award**

**Topic:** Infrastructure for Distributed Electronic Commerce

**Subtopic:** 8.13.5T

**Title:** Conversational 3-D Character On-line Agents

**NIST OU:** 890

**Firm:** Seamless Solutions, Inc.
3504 Lake Lynda Drive Suite 390
Orlando, FL 32817

**Principal Investigator:** Edward Sims
**Phone:** 407-737-7309

**Award Amount:** $300,000.00

**Abstract:** The increasing use of the Internet for commerce poses challenges for communicating information about product features, support, and operation. Studies have shown that face-to-face demonstration of products can provide far more information than the text and still images typically found on web sites today. However, bandwidth requirements and support costs limit the effectiveness of live video as a solution.

This Small Business Innovation Research Phase 2 project will develop a fully functional prototype of an Internet-based 3D Virtual Human Agent capable of real-time, natural language interaction that can demonstrate the features, operation, and support of new products. This project will be: (1) developed to operate on low-cost PC hardware; (2) demonstrated in a standard Internet browser environment, using World Wide Web standards; and (3) fully consistent with the standards being developed by the Humanoid Animation )H-ANIM) working group of the Web3D Consortium. We will integrate this Virtual Human Agent with a leading commercial Internet Agent or "bot" technology and demonstrate the effectiveness of this solution in a commercial product support application.

**Commercial Applications:** A communicating 3D Virtual Human Agent, that performs tasks in response to natural language commands, can enable new modes of communicating product information and customer support over the Internet. When linked with real-time education, training, and entertainment software, the same NLP/VH Agent can provide an immediacy and flexibility of interaction not available with "point and click" or joystick type applications.

**FY2000 Phase II Award**

**Topic:** Microelectronics Manufacturing Infrastructure

**Subtopic:** 8.17.1T

**Title:** Nanometer-scale Semiconductor Analysis with Tunable Microwave Microscopy and Spectroscopy

**NIST OU:** 830

**Firm:** Atolytics, Inc.
545 Orlando Avenue
State College, PA 16803-3479

**Principal Investigator:** Gregory McCarty
**Phone:** 814-863-8220

**Award Amount:** $300,000.00

**Abstract:** We will apply and continue to develop tunable microwave frequency scanning tunneling microscopy and spectroscopy for 2-D and 3-D dopant profiling of semiconductors. In Phase 2, we will use existing state-of-the art instrumentation at Penn State. We will demonstrate and optimize the resolution of the ACSTM by using NIST/Sematech standard samples. In Phase 1, we showed that we are indeed sensitive to dopant density and identity, and have high resolution on these samples. We will fill an important gap in the international Technology Roadmap for Semiconductors in profiling dopants where today there is no known solution. Our tunable microwave frequency scanning tunneling microscopes are extremely versatile in terms of measuring linear and nonlinear, scalar and vector, and transmitted and reflected signals over a wide range of biases and frequencies (0-20 GHz). In Phase 2, we will further determine which measurements are information-rich in terms of dopant profiling and then will show how to generate images of dopant profiles on this basis. We will continue to participate in the industry-wide Working Group on this problem, so that our advances can quickly be included in the strategic planning of the semiconductor industry's march to ever smaller features.

**Commercial Applications:** The relevant commercial applications for the work described in this proposal are to image the dopant profiles in semiconductor devices. The International Technology Roadmap for Semiconductors points out there are no known solutions for measuring dopant profiles with the resolution required even for current devices! The dopant profiles determine the device function (or malfunction), and we are creating an analytical tool to meet this need.

**FY2000 Phase II Award**

**Topic:** Microelectronics Manufacturing Infrastructure

**Subtopic:** 8.17.10T

**Title:** Innovative Manufacturing Methods for Diamond Indenters

**NIST OU:** 820

**Firm:** Gilmore Diamond Tools, Inc.
43 Roger Williams Avenue
East Providence, RI 02916

**Principal Investigator:** Michael Mihalec
**Phone:** 401-438-0717

**Award Amount:** $297,000.00

**Abstract:** There is a universal need with the Rockwell hardness testing community for NIST Standard Reference Materials (SRM) grade Rockwell diamond indenters. There is primarily one significant difference between these diamond indenters and the standard working grade indenter. SRM grade indenters have tighter tolerances on the geometric parameters than the working grade. Now with the increased precision available in measurement equipment today, those tighter tolerances become measurable. That is essentially the problem and the opportunity. The days of holding the profile up on a 200X optical comparator to visually check whether the radius follows the curve are over. Characterizing the microform on the tip of a Rockwell diamond indenter requires specialized measurement systems. Creating the microform to comply with the stringent tolerances for SRM grade indenters requires equally new manufacturing techniques. In continuation of our Phase 1 work we propose to develop new manufacturing techniques capable of generating the tighter Rockwell microform on a substantially more consistent basis. We intend to further our investigation into advanced grinding systems. We will also continue pursuit of consistency by varying the wheel grit size, RPM, and spindle speed while maintaining the "one spindle" approach for grind, policy and radius.

**Commercial Applications:** The potential commercial applications of the research results are very promising. NIST is seriously interested in securing a consistent source for Rockwell diamond indenters, which meet the stringent geometrical and performance requirements necessary for the National Standard. NIST needs to be able to provide Standard Reference Materials (SRM) diamond indenters to industry. There is a substantial global market as well. The NIST parameters adhere to ISO specifications and to most (if not all) of the standardizing agencies worldwide. These organizations also desire indenters compliant with the specifications. Beyond the standardizing agencies, industry all over the world is in need of these tools. In an economically global marketplace where all the requirements are becoming universal, the aim of business is to be ISO, NIST, NAMAS, etc. compliant. The traceability provided by these indenters brings everyone a step closer to this goal.

**FY2000 Phase II Award**

**Topic:** Microfabrication and Micromachining

**Subtopic:** 8.18.5T

**Title:** High Resolution, 3-D, Digital Image Calibration System for Brachytherapy Sources

**NIST OU:** 840

**Firm:** Industrial Quality Inc.
640 E. Diamond Avenue Suite C
Gaithersburg, MD 20877-5323

**Principal Investigator:** Harold Berger
**Phone:** 301-948-2460

**Award Amount:** $300,000.00

**Abstract:** A novel radiation imaging system is proposed for use in mapping the three-dimensional radiation intensity emitted from relatively low activity brachytherapy sources. A scintillator-CCD camera system will display high contrast and high spatial resolution images that provide a full three-dimensional map of the photon or particle radiation emitted from the radioactive source. Camera results are presented in seconds and analysis software will permit straight-forward determination of source radiation emission uniformity in both radial and axial directions. The camera system has shown the potential for spatial resolution within the desired 0.1 mm limit. The developed scintillator-camera system will permit measurements to be made in an efficient manner, in an operational mode much simpler to use as compared to measurement/calibration instruments presently available. Two scintillator-camera configurations are proposed for evaluation in this Phase 2 project. The most promising approach will be further developed as a prototype camera instrument for evaluation as a source measurement and calibration system. The proposed Phase 2 team includes expertise in radiation dosimetry and calibration and radiation imaging. Camera system measurements will be compared to those of a similar source calibrated by conventional methods, thereby providing the means to relate the camera system measurements to radiation dose.

**Commercial Applications:** Advantages include rapid and complete response and detailed information about radiation emitted from specific surfaces of the source. Markets foreseen for an easy-to-use camera system that can provide radiation emission data from radioactive sources in both the radial and axial directions include manufacturers of radioactive sources, organizations that offer source calibration services and, particularly, radiation oncology centers that are the primary users of brachytherapy sources. Considering only the oncology market, the 2,500 or more U.S. and foreign oncology centers represent a potential $100 million market for this new instrument.

**FY2000 Phase II Award**

**Topic:** Photonics Manufacturing

**Subtopic:** 8.20.6T

**Title:** Nano-Ceramic Tools for Precision Machining

**NIST OU:** 820

**Firm:** Nanopac Technologies
35 Hutchinson Road
Allentown, NJ 08501

**Principal Investigator:** Dr. James Colaizzi
**Phone:** 609-758-5200

**Award Amount:** $300,000.00

**Abstract:** This project merges two breakthroughs in nanomaterials research to produce a new generation of materials of single phase and composite materials with an extraordinarily fine scale and uniform structure for use in high performance cutting tools. By combining Rapid Solidification Processing of metastable ceramic powders and Transformation Assisted Consolidation (TAC) of compacts, we are able for the first time to produce bulk samples that have high density while still retaining the nanoscale grain size.

For single phase ceramics, we are able to produce sintered structures with grain sizes smaller than 20nm at 99+% of theoretical density. Our previous research into these materials has shown that such nano-ceramics have extraordinarily high wear resistance, low friction, and high strength.

In case of ceramic composites, we were able to produce a homogeneous distribution of two or more ceramic phases, each of which retards the grain coarsening of the other and provides mechanical reinforcement. The result is a material with a grain size 10nm and that combines the advantages of composite structures with those of nanomaterials.

Our goal in this project is to extend the technologies developed to data to produce ceramic nano-nanocomposites in which all the phases are nanoscale and are suitable for high performance cutting tools. These components will have properties such as toughness and wear resistance that are superior to conventional ceramics and composites whose grain sizes have m dimensions.

**Commercial Applications:** Ceramic nano-nano-composites have wide applicability where high strength, high toughness, excellent wear resistance and high temperature capability are needed. This includes cutting tools, engine components, and heat resistant materials such as brake, valve seats, cylinder liners and so forth.