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FY 2003 Scientific and Technical Reports, Articles, Papers, and Presentations

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December 2004
FOREWORD

In accordance with the NASA Space Act of 1958, the George C. Marshall Space Flight Center (MSFC) has provided for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

Since July 1, 1960, when MSFC was organized, the reporting of scientific and engineering information has been considered a prime responsibility of the Center. Our credo has been that “research and development work is valuable, but only if its results can be communicated and made understandable to others.”
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TM—2002–212049        October 2002

Basic mechanical properties; i.e., ultimate tensile strength, yield strength, percent elongation, and elastic modulus, were obtained for the aluminum-beryllium alloy, AlBeMet162, at cryogenic (–195.5 °C (–320 °F) and –252.8 °C (–423 °F)) temperatures. The material evaluated was purchased to the requirements of SAE–AMS7912, “Aluminum-Beryllium Alloy, Extrusions."

TM—2003–212286        February 2003

A number of recent advanced theories related to torsion properties of the space-time matrix predict the existence of an interaction between classically spinning objects. Indeed, some experimental data suggest that spinning magnetic bodies discernibly interact with Earth’s natural fields. If a rotating body modifies the geometry of space-time, then nuclear spins could be used for detection. Thus, assuming a spinning body induces a torsion field, a sensor based on the giant magnetoresistance effect would detect local changes. Experimentally, spinning a brass wheel shielded from Earth’s magnetic field showed no measurable change in signals; without shielding, a Faraday disc phenomenon was observed. Unexpected experimental measurements from the nonaxial Faraday disc configuration were recorded, and a theoretical model was derived to explain them.

TM—2003–212345        April 2003
Dwell Time and Surface Parameter Effects on Removal of Silicone Oil From D6ac Steel Using TCA. R.E. Boothe. Materials, Processes, and Manufacturing Department, Engineering Directorate.

This study was conducted to evaluate the impact of dwell time, surface roughness, and the surface activation state on 1,1,1-trichloroethane’s (TCA’s) effectiveness for removing silicone oil from D6ac steel. Silicone-contaminated test articles were washed with TCA solvent, and then the surfaces were analyzed for residue, using Fourier transform infrared spectroscopy. The predominant factor affecting the ability to remove the silicone oil was surface roughness.

TM—2003–212500        June 2003

A thermal interface material is one of the many tools often used as part of the thermal control scheme for space-based applications. Historically, at Marshall Space Flight Center, CHO-THERM 1671 has primarily been used for applications where an interface material was deemed necessary. However, numerous alternatives have come on the market in recent years. It was decided that a number of these materials should be tested against each other to see if there were better performing alternatives. The tests were done strictly to compare the

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thermal performance of the materials relative to each other under repeatable conditions and do not take into consideration other design issues, such as off-gassing, electrical conduction, isolation, etc. The purpose of this Technical Memorandum is to detail the materials tested, test apparatus, procedures, and results of these tests. The results show that there are a number of better performing alternatives now available.

TM—2003–212501  June 2003

The goal of this effort was to develop a digital motor controller using field programmable gate arrays (FPGAs). This is a more rugged approach than a conventional microprocessor digital controller. FPGAs typically have higher radiation tolerance than both the microprocessor and memory required for a conventional digital controller. Furthermore, FPGAs can typically operate at higher speeds. (While speed is usually not an issue for motor controllers, it can be for other system controllers.) Other than motor power, only a 3.3-V digital power supply was used in the controller; no analog bias supplies were used. Since most of the circuit was implemented in the FPGA, no additional parts were needed other than the power transistors to drive the motor. The benefits that FPGAs provide over conventional designs—lower power and fewer parts—allow for smaller packaging and reduced weight and cost.

TM—2003–212502  June 2003

This effort demonstrates that health management can be taken to the component level for electromechanical systems. The same techniques can be applied to take any health management system to the component level, based on the practicality of the implementation for that particular system. This effort allows various logic schemes to be implemented for the identification and management of failures. By taking health management to the component level, integrated vehicle health management systems can be enhanced by protecting box-level avionics from being shut down in order to isolate a failed computer.

TM—2003–212503  June 2003

In order to help identify contamination found on bonding surfaces, optical surfaces, or other items, the Materials Contamination Team of the Materials, Processes, and Manufacturing Department at Marshall Space Flight Center (MSFC) has initiated the development of an infrared database containing MSFC process materials and residues. Process materials analyzed to date using infrared spectroscopy for transferable and extractable contamination have included gloves, wiper cloths, solvents, bagging materials, etc. Significant findings included silicone contamination on several gloves and observations of extractables from the majority of materials tested.

TM—2003–212633  July 2003

To determine composite material properties’ effects from processing variables, a 3 factorial designed experiment with two replicates was conducted. The factors were cure method (oven versus autoclave), layup (hand versus tape-laying machine), and thickness (8 versus 52 ply). Four material systems were tested: AS4/3501–6, IM7/8551–7, IM7/F655 bismaleimide (BMI), and shear tests on IM7/F584. Material properties were $G_{12}$, $v_{12}$, $E_1^C$, and $E_2^C$. Since the samples were necessarily nonstandard, strengths, though recorded, cannot be considered valid. Void content was also compared.

Autoclave curing helped material properties for the low modulus fiber material but showed little benefit for higher stiffness fibers. The number of plies was very important for epoxy composites but not for the BMI. $E_1$ was generally unaffected by any factor.

Particularly high void content did correlate to reduced properties. Autoclave curing reduced void content over oven curing but a moderate amount of voids, <1 percent void content, did not correlate with material properties.

Oven cures and hand layups can produce high-quality parts. Part thickness of epoxy composites is important, though cure optimization may improve performance. Significant variations can be caused by processing and it is important that test coupons always reflect the layup and processes of the final part.


This Technical Memorandum lists the significant publications and presentations of the Science Directorate during the period January 1–December 31, 2002. Entries in the main part of the document are categorized according to NASA Reports (arranged by report number), Open Literature, and Presentations (arranged alphabetically by title). Most of the articles listed under Open Literature have appeared in refereed professional
journals, books, monographs, or conference proceedings. Although many published abstracts are eventually expanded into full papers for publication in scientific and technical journals, they are often sufficiently comprehensive to include the significant results of the research reported. Therefore, published abstracts are listed separately in a subsection under Open Literature. Questions or requests for additional information about the entries in the report should be directed to Dr. A.F. Whitaker (SD01, 256-544-2481) or one of the authors.

**TM—2003–212636**

Manufacturing polymer hardware during space flight is currently outside the state of the art. A process called fused deposition modeling (FDM) can make this approach a reality by producing net-shaped components of polymer materials directly from a CAE model. FDM is a rapid prototyping process developed by Stratasys, Inc., which deposits a fine line of semimolten polymer onto a substrate while moving via computer control to form the cross-sectional shape of the part it is building. The build platen is then lowered and the process is repeated, building a component directly layer by layer. This method enables direct net-shaped production of polymer components directly from a computer file. The layered manufacturing process allows for the manufacture of complex shapes and internal cavities otherwise impossible to machine. This task demonstrated the benefits of the FDM technique to quickly and inexpensively produce replacement components or repair broken hardware in a Space Shuttle or Space Station environment.

The intent of the task was to develop and fabricate an FDM system that was lightweight, compact, and required minimum power consumption to fabricate ABS plastic hardware in microgravity. The final product of the shortened task turned out to be a ground-based breadboard device, demonstrating miniaturization capability of the system.

**TM—2003–212690**

The primary objective of this research was to determine the processes and feasibility of using commercial off-the-shelf PC104 hardware for flight applications. This would lead to a faster, better, and cheaper approach to low-budget programs as opposed to the design, procurement, and fabrication of space flight hardware. This effort will provide experimental evaluation with results of flight environmental testing. Also, a method and/or suggestion used to bring test hardware up to flight standards will be given. Several microgravity programs, such as the Equiaxed Dendritic Solidification Experiment, Self-Diffusion in Liquid Elements, and various other programs, are interested in PC104 environmental testing to establish the limits of this technology.

**TM—2003–212692**

The objective of this investigation was to examine the relationship between irradiation level (proton dose), microstructure, and stress levels in chemical vapor-deposited diamond and polysilicon films using cross-sectioned specimens. However, the emphasis was placed on the diamond specimen because diamond holds much promise for use in advanced technologies. The use of protons allows not only the study of the charged particle that may cause the most microstructural damage in Earth-orbit microelectromechanical systems (MEMS) devices, but also allows the study of relatively deeply buried damage inside the diamond material. Using protons allows these studies without having to resort to megaelectronvolt implant energies that may create extensive damage due to the high energy that is needed for the implantation process. Since MEMS devices operating in space will not have an opportunity to reverse radiation damage via annealing, only nonannealed specimens were investigated. The following three high spatial resolution techniques were used to examine these relationships: (1) Scanning electron microscopy, (2) micro-Raman spectroscopy, and (3) micro x-ray diffraction.
A simple power law model consisting of a single spectral index, $\alpha_1$, is believed to be an adequate description of the galactic cosmic-ray (GCR) proton flux at energies below $10^{13}$ eV, with a transition at the knee energy, $E_k$, to a steeper spectral index $\alpha_2 > \alpha_1$ above $E_k$. The maximum likelihood (ML) procedure was developed for estimating the single parameter $\alpha_1$ of a simple power law energy spectrum and generalized to estimate the three spectral parameters of the broken power law energy spectrum from simulated detector responses and real cosmic-ray data. The statistical properties of the ML estimator were investigated and shown to have the three desirable properties: (P1) consistency (asymptotically unbiased), (P2) efficiency (asymptotically attains the Cramer-Rao minimum variance bound), and (P3) asymptotically normally distributed, under a wide range of potential detector response functions. Attainment of these properties necessarily implies that the ML estimation procedure provides the best unbiased estimator possible.

While simulation studies can easily determine if a given estimation procedure provides an unbiased estimate of the spectra information, and whether or not the estimator is approximately normally distributed, attainment of the Cramer-Rao bound (CRB) can only be ascertained by calculating the CRB for an assumed energy spectrum-detector response function combination, which can be quite formidable in practice. However, the effort in calculating the CRB is very worthwhile because it provides the necessary means to compare the efficiency of competing estimation techniques and, furthermore, provides a stopping rule in the search for the best unbiased estimator. Consequently, the CRB for both the simple and broken power law energy spectra are derived herein and the conditions under which they are attained in practice are investigated.

The ML technique is then extended to estimate spectra information from an arbitrary number of astrophysics data sets produced by vastly different science instruments. This theory and its successful implementation will facilitate the interpretation of spectral information from multiple astrophysics missions and thereby permit the derivation of superior spectral parameter estimates based on the combination of data sets.

Marshall Space Flight Center has developed world-class space environmental effects testing facilities to simulate the space environment. The combined environmental effects test system exposes temperature-controlled samples to simultaneous protons, high- and low-energy electrons, vacuum ultraviolet (VUV) radiation, and near-ultraviolet (NUV) radiation. Separate chambers for studying the effects of NUV and VUV at elevated temperatures are also available. The Atomic Oxygen Beam Facility exposes samples to atomic oxygen of 5 eV energy to simulate low-Earth orbit (LEO). The LEO space plasma simulators are used to study current collection to biased spacecraft surfaces, arcing from insulators and electrical conductivity of materials. Plasma propulsion techniques are analyzed using the Marshall magnetic mirror system. The micro light gas gun simulates micrometeoroid and space debris impacts.

Candidate materials and hardware for spacecraft can be evaluated for durability in the space environment with a variety of analytical techniques. Mass, solar absorptance, infrared emittance, transmission, reflectance, bidirectional reflectance distribution function, and surface morphology characterization can be performed. The data from the space environmental effects testing facilities, combined with analytical results from flight experiments, enable the Environmental Effects Group to determine optimum materials for use on spacecraft.
The production of onboard electrical power by pulse detonation engines is problematic in that they generate no shaft power; however, pulse detonation-driven magnetohydrodynamic (MHD) electrical power generation represents one intriguing possibility for attaining self-sustained engine operation and generating large quantities of burst power for onboard electrical systems. To examine this possibility further, a simple heat-sink apparatus was developed for experimentally investigating pulse detonation-driven MHD generator concepts. The hydrogen-oxygen-fired driver was a 90-cm-long stainless steel tube having a 4.5-cm-square internal cross section and a short Schelkin spiral near the head-end to promote rapid formation of a detonation wave. The tube was intermittently filled to atmospheric pressure and seeded with a CsOH/methanol spray prior to ignition by electrical spark. The driver exhausted through an aluminum nozzle having an area contraction ratio of $A^*/A_e = 1/10$ and an area expansion ratio of $A_e/A^* = 3.2$ (as limited by available magnet bore size). The nozzle exhausted through a 24-electrode segmented Faraday channel (30.5-cm active length), which was inserted into a 0.6-T permanent magnet assembly. Initial experiments verified proper driver operation with and without the nozzle attachment, and head-end pressure and time-resolved thrust measurements were acquired. The exhaust jet from the nozzle was interrogated using a polychromatic microwave interferometer yielding an electron number density on the order of $10^{12}$ cm$^{-3}$ at the generator entrance. In this case, MHD power generation experiments suffered from severe near-electrode voltage drops and low MHD interaction; i.e., low flow velocity, due to an inherent physical constraint on expansion with the available magnet. Increased scaling, improved seeding techniques, higher magnetic fields, and higher expansion ratios are expected to greatly improve performance.

The performance of conventional thermal propulsion systems is fundamentally constrained by the specific energy limitations associated with chemical fuels and the thermal limits of available materials. Electromagnetic thrust augmentation represents one intriguing possibility for improving the fuel consumption of thermal propulsion systems, thereby increasing overall specific energy characteristics; however, realization of such a system requires an extremely high-energy-density electrical power source as well as an efficient plasma acceleration device. This Technical Publication describes the development of an experimental research facility for investigating the use of cross-field magnetohydrodynamic (MHD) accelerators as a possible thrust augmentation device for thermal propulsion systems. In this experiment, a 1.5-MW$_e$ Aerotherm arc heater is used to drive a 2-MW$_e$ MHD accelerator. The heat-sink MHD accelerator is configured as an externally diagonalized, segmented channel, which is inserted into a large-bore, 2-T electromagnet. The performance analysis and engineering design of the flow path are described as well as the parameter measurements and flow diagnostics planned for the initial series of test runs.

Fillets are one of the most common design features in structures. Proper finite element modeling of these fillets can frequently be problematic though. If the ratio of the fillet radius to the wall thickness is relatively large, the fillet cannot be ignored because it contributes significantly to structural stiffness, and although the most appropriate element for modeling the structure in general may be the plate element, geometric representation of the fillets requires the use of solid elements. This problem is the motivation for the development of a method that uses “bridge” plate elements connecting the tangent points of the fillet to accurately represent its stiffness and mass. The methodology equates the rotational deflection at the tangent point, derived from the proposed bridge system, with an analytical solution of the fillet itself to generate a pseudo Young’s Modulus and thickness for use in the bridge plates. The method was tested on a typical filleted structure, with the bridge method yielding modal analysis results as accurate as a high-fidelity solid model when compared to modal test but with a 90-percent reduction in number of degrees of freedom. This capability could prove extremely useful in design, dynamic, deflection, and preliminary stress analysis, and optimization.
Magnetic flux compression reaction chambers offer considerable promise for controlling the plasma flow associated with various micronuclear/chemical pulse propulsion and power schemes, primarily because they avoid thermalization with wall structures and permit multicycle operation modes. The major physical effects of concern are the diffusion of magnetic flux into the rapidly expanding plasma cloud and the development of Rayleigh-Taylor instabilities at the plasma surface, both of which can severely degrade reactor efficiency and lead to plasma-wall impact. A physical parameter of critical importance to these underlying magnetohydrodynamic (MHD) processes is the magnetic Reynolds number \( (R_m) \), the value of which depends upon the product of plasma electrical conductivity and velocity. Efficient flux compression requires \( R_m \gg 1 \), and a thorough understanding of MHD phenomena at high magnetic Reynolds numbers is essential to the reliable design and operation of practical reactors. As a means of improving this understanding, a simplified laboratory experiment has been constructed in which the plasma jet ejected from an ablative pulse plasma gun is used to investigate plasma armature interaction with magnetic fields. As a prelude to intensive study, exploratory experiments were carried out to quantify the magnetic Reynolds number characteristics of the plasma jet source. Jet velocity was deduced from time-of-flight measurements using optical probes, and electrical conductivity was measured using an inductive probing technique. Using air at 27-inHg vacuum, measured velocities approached 4.5 km/s and measured conductivities were in the range of 30 to 40 kS/m.

**TP—2003–212342**

March 2003

Flightweight Carbon Nanotube Magnet Technology.


Virtually all plasma-based systems for advanced airborne/spaceborne propulsion and power depend upon the future availability of flightweight magnet technology. Unfortunately, current technology for resistive and superconducting magnets yields system weights that tend to counteract the performance advantages normally associated with advanced plasma-based concepts. The ongoing nanotechnology revolution and the continuing development of carbon nanotubes (CNT), however, may ultimately relieve this limitation in the near future. Projections based on recent research indicate that CNTs may achieve current densities at least three orders of magnitude larger than known superconductors and mechanical strength two orders of magnitude larger than steel. In fact, some published work suggests that CNTs are superconductors. Such attributes imply a dramatic increase in magnet performance-to-weight ratio and offer real hope for the construction of true flightweight magnets. This Technical Publication reviews the technology status of CNTs with respect to potential magnet applications and discusses potential techniques for using CNT wires and ropes as a winding material and as an integral component of the containment structure. The technology shortfalls are identified and a research and technology strategy is described that addresses the following major issues: (1) Investigation and verification of mechanical and electrical properties, (2) development of tools for manipulation and fabrication on the nanoscale, (3) continuum/molecular dynamics analysis of nanotube behavior when exposed to practical bending and twisting loads, and (4) exploration of innovative magnet fabrication techniques that exploit the natural attributes of CNTs.

**TP—2003–212634**

July 2003


The Materials Contamination Team of the Environmental Effects Group, Materials, Processes, and Manufacturing Department, has been recognized for its contribution to space flight, including space transportation, space science, and flight projects, such as the reusable solid rocket motor, Chandra X-Ray Observatory, and the *International Space Station*. The Materials Contamination Team’s realm of responsibility encompasses all phases of hardware development including design, manufacturing, assembly, test, transportation, launchsite processing, on-orbit exposure, return, and refurbishment, if required. Contamination is a concern in the Space Shuttle with sensitive bondlines and reactive fluid (liquid oxygen) compatibility as well as for sensitive optics, particularly spacecraft, such as the Hubble Space Telescope and Chandra X-Ray Observatory.

The Materials Contamination Team has a variety of facilities and instrumentation capable of contaminant detection, identification, and monitoring. The team addresses material applications dealing with environments, including production facilities, clean rooms, and on-orbit exposure. The team of engineers and technicians also develops and evaluates new surface cleanliness inspection technologies. Databases are maintained by the team for process materials as well as outgassing and optical compatibility test results for specific environments.
The 2002 Microgravity Materials Science Conference was held June 25–26, 2002, at the Von Braun Center, Huntsville, Alabama. Organized by the Microgravity Materials Science Discipline Working Group, sponsored by the Physical Sciences Research Division, NASA Headquarters, and hosted by NASA Marshall Space Flight Center and member institutions under the COoperative Research in Biology and Materials Science (CORBAMS) agreement, the conference provided a forum to review the current research and activities in materials science, discuss the envisioned long-term goals, highlight new crosscutting research areas of particular interest to the Physical Sciences Research Division, and inform the materials science community of research opportunities in reduced gravity. An abstracts book was published and distributed at the conference to the approximately 240 people attending, who represented industry, academia, and other NASA Centers. The proceedings on this CD-ROM are comprised of the research reports submitted by the Principal Investigators in the Microgravity Materials Science program.


This document contains the proceedings of the 35th annual NASA Aerospace Battery Workshop, hosted by the Marshall Space Flight Center, November 19–21, 2002. The workshop was attended by scientists and engineers from various agencies of the U.S. Government, aerospace contractors, and battery manufacturers, as well as international participation in like kind.

The subjects covered included nickel-hydrogen, lithium-ion, nickel-metal hydride, lithium-sulfur, lithium-iron disulfide, and silver-zinc technologies.
A detector array charge collection model has been developed for use as an engineering tool to aid in the design of optical sensor missions for operation in the space radiation environment. This model is an enhancement of the prototype array charge collection model that was developed for the NGST program. The primary enhancements were accounting for drift-assisted diffusion by Monte Carlo modeling techniques and implementing the modeling approaches in a windows-based code. The modeling is concerned with integrated charge collection within discrete pixels in the focal plane array (FPA), with high-fidelity spatial resolution. It is applicable to all detector geometries, including monolithic charged-coupled devices (CCDs), active pixel sensors (APS), and hybrid FPA geometries based on a detector array bump-bonded to a readout integrated circuit (ROIC).

CR—2003–212637 August 2003

A model has been developed capable of calculating the electrostatic return of spacecraft-emitted molecules that are ionized and attracted back to the spacecraft by the spacecraft electric potential on its surfaces. The return of ionized contaminant molecules to charged spacecraft surfaces is very important to all altitudes. It is especially important at geosynchronous and interplanetary environments, since it may be the only mechanism by which contaminants can degrade a surface. This model is applicable to all altitudes and spacecraft geometries. In addition, results of the model will be completed to cover a wide range of potential space systems.

CR—2003–212638 August 2003

An experiment on the Microelectronics and Photonics Test Bed (MPTB) was testing field programmable gate arrays using spot shields to extend the life of some of the devices being tested. It was expected that the unshielded parts would fail from a total ionizing dose (TID) and yet the opposite occurred. The data show that the devices failing from the TID effects are those with the spot shields attached. This effort is to determine the mechanism by which the environment is interacting with the high-Z material to enhance the TID in these field programmable gate arrays.

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AGASA Results and EUSO—Abstract Only. For presentation at the 28th International Cosmic Ray Conference, Tsukuba, Japan, July 31–August 7, 2003.

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PREECE, R.D. SD50
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WILSON, C.A. SD50
WOODS, P.M. SD50

Using the Chandra Project to Communicate With Underdeveloped Constituencies—Abstract Only. For presentation at the Meeting on Communicating Astronomy to the Public, Washington, DC, October 1–3, 2003.

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For presentation at the 28th International Cosmic Ray Conference, Tsukuba, Japan, July 31–August 7, 2003.

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SU, C.-H. SD46


BARNES, C.L. SD40
SNELL, E.H. BAE Systems
KUNDROT, C.E. SD40


BARRET, C. TD40

Nuclear Electric Propulsion for Outer Space Missions—Abstract Only. For presentation at the Society of Women Engineers Conference, Birmingham, AL, October 9–11, 2003.

BASHINDZHAGYAN, G.L. Moscow State University
ADAMS, J.H. SD50
BASHINDZHAGYAN, P. Moscow State University
BARANOVA, N. Moscow State University
CHRISTL, M.J. SD50
CHILINGARIAN, A. Yerevan Physics Institute
CHURPIN, I. Joint Institute for Nuclear Research
DERRICKSON, J. SD50
EGOROV, N. Research Institute of Material Science


BASHINDZHAGYAN, G.L. Moscow State University
ADAMS, J.H. SD50
BASHINDZHAGYAN, P. Moscow State University
BARANOVA, N. Moscow State University
CHRISTL, M.J. SD50
CHILINGARIAN, A. Yerevan Physics Institute
CHURPIN, I. Joint Institute for Nuclear Research
DERRICKSON, J. SD50
EGOROV, N. Research Institute of Materials Science


BAUGHER, C.R. SD41


BECKER, W.E. Max Planck Institute
SWARTZ, D.A. USRA
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ELSNER, R.F. SD50
GRINDLAY, J. Harvard-Smithsonian
MIGNANI, R. European Southern Observatory
TENNANT, A.F. SD50
BACKER, D. University of California
WEISSKOPF, M.C. SD50
Chandra X-Ray Observatory Observations of the Globular
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24—Abstract Only. For publication in The Astrophysical

BEMPORAD, A. SD50
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BERNHARDSDOTTER, E. SD46
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NG, J.D. SD46
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Huntsville, Huntsville, AL, April 11, 2003.

BEST, S. FD41
NICHOLS, K.F. FD41
BRADFORD, R.N. FD41
Utilization of Internet Protocol-Based Voice Systems
in Remote Payload Operations—Viewgraphs Only. For
presentation at the Ground System Architectures Work-
shop, Manhattan Beach, CA, March 4–6, 2003.

BJORKMAN, G. Lockheed Martin
CANTRELL, M. Lockheed Martin
CARTER, R.R. ED33
Self-Reacting Friction Stir Welding for Aluminum
Alloy Circumferential Weld Application—Abstract and
Presentation. For presentation at the AeroMat 2003 Con-
BOCCIPIO, D.J. SD60

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BOECK, W.L. Niagara University
JACOBSON, A.R. Los Alamos National Laboratory
CHRISTIAN, H.J. SD60
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BELLAMY, H. SD46

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DRESSLER, G.A.  
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ESTES, M.G. USRA
QUATTROCHI, D.A. SD60
STASIĄK, E. Intl. City/County Mgmt. Association

EVANS, J.P. Yale University
SMITH, R. Yale University
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GERRISH, H.P., JR. TD40


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SPASOJEVIC, M. STAR Laboratory
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REINISCH, B.W. University of Massachusetts


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MCALLA, E.W., JR. Global Hydrology & Climate Center
BUECHLER, D.E. National Weather Service
DARDEN, C. National Weather Service
BURKS, J. National Weather Service


GORTI, S. SD46
FORSYTHE, E.L. USRA
LAXSON, N. USRA
PUSEY, M.L. SD46


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Modeling Tetragonal Lysozyme Crystal Growth Rates—Abstract Only. For presentation at the American

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OSEI, A. Oakwood College
SHARMA, A. Alabama A&M University

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GRAY, P.A. ICRC
NEHLS, M.K. ED31
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KOUVELIOTOU, C. SD50

GRIFFIN, L.W. TD64
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GRIFFIN, L.W. TD64
DORNEY, D.J. TD64
HUBER, F.W. Riverbend Design Serv.

GRUBBS, R. MSFC
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GWALTNEY, D.A. ED17
STEINcamp, J. ED17
CORDER, E. ED17
KING, K. ED17
FERGUSON, M.I. Jet Propulsion Laboratory DUTTON, K. Madison Research Corporation


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HAGYARD, M.J. SD50
PEVTSOV, A.A. National Solar Observatory CANFIELD, R.C. Montana State University BLEHM, Z. Montana State University


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HATHAWAY, D.H. SD50


HEDAYAT, A. Sverdrup BAILEY, J.W. Sverdrup

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<tr>
<th>Author(s)</th>
<th>Affiliation</th>
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<td>FLACHBART, R.H.</td>
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<td>CASTRO-TIRADO, A.</td>
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<td>FIKES, J.C.</td>
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<td>HOWELL, J.T.</td>
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<td>MANKINS, J.C.</td>
<td>NASA Headquarters</td>
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<td>Oak Ridge National Laboratory</td>
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<td>CHO, F.</td>
<td>Johnson Space Center</td>
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<td>HOLLADAY, J.</td>
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<td>LEAHY, F.</td>
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<td>Morgan Research</td>
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<td>HJORTH, J.</td>
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<td>WOOSLEY, S.E.</td>
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<td>KOUVELITOU, C.</td>
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<td>TANVIR, N.R.</td>
<td>SD50</td>
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Elasticity and Strength of Biomacromolecular Crystals—
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Spirochaeta Americana Sp. Nov., A New Haloalkaliphilic,
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Just Being on the Internet is Old News!—Abstract Only. For presentation at the Fall Meeting of the ADP Council of the Southeastern States, Biloxi, MS, October 22–24, 2003.

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<th>Name</th>
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**Developing a Contoured Deposition Head for In Situ Tape Laying and Fiber Placement—Final Paper. For presentation at the SAMPE International Symposium & Exhibition, Long Beach, CA, May 11–15, 2003.**


**RNA Crystallization—Abstract Only. For publication in the Journal of Structural Biology, 2003.**

**Which Strategy for a Protein Crystallization Project?—Abstract Only. For publication in Cellular and Molecular Life Sciences, 2003.**

**Error Analyses of the North Alabama Lightning Mapping Array (LMA)—Abstract Only. For presentation at the International Conference on Atmospheric Electricity, Versailles, France, June 9–13, 2003.**

**Developing a Contoured Deposition Head for In Situ Tape Laying and Fiber Placement—Final Paper. For presentation at the SAMPE International Symposium & Exhibition, Long Beach, CA, May 11–15, 2003.**

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**Sunyaev-Zeldovich Effect Imaging of MACS Galaxy Clusters at z>0.5—Abstract Only.** For publication in The Astrophysical Journal, 2002.

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<td>LASZAR, J.</td>
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**Operational Experience With the Internal Thermal Control System Dual-Membrane Gas Trap—Final Paper.**

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**Cast Aluminum Alloy for High-Temperature Applications—Abstract Only.** For presentation at the TMS 132nd Annual Meeting and Exhibition, San Diego, CA, March 2–6, 2003.

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ZHU, S. SD46
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LI, C. UAB
SCRIPA, R.N. UAB
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Numerical Modeling of Thermofluid Transients During Chilldown of Cryogenic Transfer Lines—Abstract Only. For presentation at the 33rd International Conference

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Commercial Research Results From the International Space Station—Abstract Only. For presentation at the 41st AIAA Aerospace Science Meeting and Exhibit, Reno, NV, January 6–9, 2003.

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Shuttle Fuel Feedliner Cracking—Presentation. For presentation at the MSFC Fall Workshop on Fluids, Huntsville, AL, November 19–21, 2002.
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