ENS fusion technology

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KrF LASERS FOR INERTIAL CONFINEMENT FUSION

PREFACE: SPECIAL ISSUE ON KrF LASERS FOR INERTIAL CONFINEMENT FUSION

Donald J. Dudziak

Donald J. Dudziak (BS, marine engineering, 1956; MS, physics, 1957; PhD, applied mathematics, 1962) is presently section leader for High Technology Systems Studies at Los Alamos National Laboratory. Previously he was on sabbatical leave at EIR in Switzerland to pursue fusion reactor systems analysis. His past responsibilities have included transport and reactor theory group leader, research in shielding analysis, cross-section technology (ENDF), and naval reactors design. He has also served as visiting professor of nuclear engineering and adjunct professor of mathematics.

KrF FOR FUSION: AN OVERVIEW OF LASER ISSUES

Reed J. Jensen

Reed J. Jensen (PhD, physical chemistry, Brigham Young University, 1965) joined Los Alamos National Laboratory's (LANL) GMX Division following a postdoctoral appointment at the University of California, Berkeley. Following a 2-year teaching experience with Brigham Young University, he returned to LANL to initiate a program in chemical laser research. He played a key role in advancing the technology of high-energy pulsed chemical lasers. His experience with the interaction of laser radiation and chemical kinetics led him directly into the field of laser isotope separation. During this period he, along with several coworkers, advanced the concept for the molecular laser isotope separation process. His promotion to the post of assistant division leader of the Laser Division was followed in 1976 by an appointment as alternate division leader of the newly formed Applied Photochemistry Division. In 1980 he was named division leader of the Applied Photochemistry Division and program manager for molecular laser isotope separation. In 1981 he was named deputy associate director for molecular laser isotope separation. After serving as manager of plasma separation in the plutonium program, he was named program manager of the Krypton Fluoride Laser Program and associate Physics Division leader. In 1986 he was named deputy associate director for research at LANL with line management responsibilities for six technical divisions.

DEVELOPMENT OF A 1-kJ KrF LASER SYSTEM FOR LASER FUSION RESEARCH

Yoshirou Owadano
Isao Okuda
Mitsumori Tanimoto
Yuji Matsumoto
Takeshi Kasai
Masaaki Yano






Yoshirou Owadano (top right) (PhD, University of Tokyo, Japan, 1979) is a senior researcher of the laser-plasma group at the Electrotechnical Laboratory (ETL), Ibaraki, Japan. He has been engaged in the generation of the fourth harmonic of the Nd-glass laser light target experiment and in high-power KrF laser development. He stayed at Rutherford Appleton Laboratory, United Kingdom, from 1984 to 1985 as a visiting scientist in the KrF laser group. He is currently responsible for KrF laser system design and electron-beam (*e*-beam) amplifier development. **Isao Okuda** (top left) (MS, Tokyo Institute of Technology, Japan, 1983) is a researcher of the laser-plasma group at ETL. He has been engaged in the development of the high-power KrF laser and is currently pursuing efficient operation of the *e*-beam amplifiers. **Mitsumori Tanimoto** (center right) (PhD, University of Tokyo, Japan, 1971) is a senior researcher of the laser-plasma group at ETL. He has been engaged in both the laser-plasma interaction experiment and high-power laser development. He was a visiting scientist at the Max-Planck Institute for Plasma Physics, Federal Republic of Germany, from 1971 to 1972. He currently serves as general coordinator of experiments and is interested in kinetics and efficient high-power density operation of the KrF laser. **Yuji Matsumoto** (center left) (MS, electrical engineering, Osaka University, Japan, 1974) is a senior researcher of the laser-plasma group at ETL. He has been engaged in the laser-plasma interaction experiment and the Raman pulse compression experiment. He was a visiting scientist at Rutherford Appleton Laboratory, United Kingdom, from 1983 to 1984. He is currently responsible for the pulse compression system. **Takeshi Kasai** (bottom right) (BS, electrical engineering, Nagoya University, Japan, 1965) previously served as a senior researcher of the laser-plasma group at ETL. He was engaged in high-power Nd-glass and KrF laser development. He joined Fuji Electric Cooperate Research and Development Ltd. in April 1986 and is engaged in a commercial laser project. **Masaaki Yano** (bottom left) (PhD, Tokyo Institute of Technology, Japan, 1969) is the chief of the laser-plasma group at ETL. He is responsible for long-range planning of Nd-glass and KrF laser development and target experiments. He is also taking part in *e*-beam amplifier development. He was a visiting scientist at Cornell University from 1973 to 1974.

DEVELOPMENT OF AN ELECTRON-BEAM-PUMPED HIGH-POWER KrF LASER AS A SHORT-PULSE AMPLIFIER

Akira Endoh
Masayoshi Watanabe
Shuntaro Watanabe

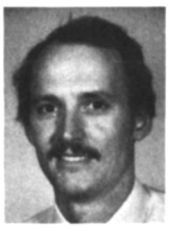


Akira Endoh (top) (BS, Keio University, Tokyo, Japan, 1973; PhD, Tokyo Institute of Technology, Tokyo, Japan, 1981) has worked with the laser physics group of the Institute for Solid State Physics, University of Tokyo (UT) since 1981. He has developed high output power discharge-pumped and electron-beam-pumped excimer lasers as amplifiers in the picosecond excimer laser system. **Masayoshi Watanabe** (center) (BS, 1978, and ME, 1980, applied physics, UT, Japan) joined the Institute for Solid State Physics in 1982. He has been involved in the research program on the high-power picosecond excimer laser system. **Shuntaro Watanabe** (bottom) (BS, 1970; MS, 1972; and PhD, 1975, applied physics, UT, Japan) was engaged in research on the excitation mechanisms of metal vapor lasers from 1970 to 1975. In 1975, he joined the staff of the Electro-Technical Laboratory, Tsukuba, Japan. From 1975 to 1981, he was engaged in the research and development of excimer lasers. He

visited the National Research Council of Canada from 1979 to 1980, where he was engaged in the development of wide aperture discharge rare-gas halide lasers. In 1981, he joined the Institute for Solid State Physics, UT. Since then, he has conducted the development of a picosecond high-power, rare-gas halide laser system and basic research on vacuum and extreme ultraviolet lasers. He is currently an associate professor.

AURORA MULTIKILOJOULE KrF LASER SYSTEM PROTOTYPE FOR INERTIAL CONFINEMENT FUSION

Louis A. Rosocha
John A. Hanlon
John McLeod
Michael Kang
Birchard L Kortegaard
Michael D. Burrows
P. Stuart Bowling



Louis A. Rosocha (top right) (BS, physics, University of Arkansas–Fayetteville, 1972; MS, 1974, and PhD, 1979, physics, University of Wisconsin–Madison), in his dissertation, researched experimental and theoretical investigations of the plasma chemistry of transient electrical discharges in oxygen, the associated production of ozone, and the application of relativistic electron beam physics and pulsed power technology to the excitation of proposed liquid excimer lasers. While finishing his doctoral work, he joined the National Research Group in Madison, Wisconsin, where he was involved in research, development, and manufacturing related to pulsed ultraviolet and dye lasers, high-voltage switches, and ozone generators. In 1981, he joined Los Alamos National Laboratory (LANL), where he served as a staff physicist, technical manager, and assistant test director on the Antares CO_2 and Aurora KrF inertial confinement fusion (ICF) projects. In 1984, Rosocha was appointed project manager for the Aurora project. On this project, he is in charge of the overall design, construction, and testing activities necessary to build a multikilojoule angular-multiplexed KrF laser system prototype for inertial fusion. In addition, he currently serves as the acting deputy group leader for the pulsed power systems group at LANL. **John A. Hanlon** (top left) (BS, 1959, and MS, 1961, electrical engineering, University of Nebraska; PhD, electrical engineering, University of Arizona, Tucson, 1970) has been a staff member at LANL since 1977. He has participated as an optical engineer on the Helios and the Aurora laser fusion programs. Prior to coming to LANL he did research and development on optical resonators as a civilian at the Air Force Weapons Laboratory in Albuquerque, New Mexico. **John McLeod** (center right) (Harvard College, 1954; PhD, physics, Princeton University, 1962) joined LANL in March 1960. He has participated in programs in space nuclear propulsion, magnetic confinement fusion, and ICF. His primary role in the ICF program has been development of laser drivers, including Nd: glass, carbon dioxide, and krypton fluoride. **Birchard L. Kortegaard** (bottom left) (BSEE, Massachusetts Institute of Technology; MSEE, University of California, Berkeley) is a project engineer for the HILAC and also the SUPERHILAC at Berkeley. He is an engineering consultant for ASTRON at Lawrence Livermore National Laboratory and for the accelerator at Darmstadt, Federal Republic of Germany. He is section leader for three major laser systems at LANL and a winner of a 1985 distinguished performance award. The work in this paper won a 1986 IR-100 award. **P. Stuart Bowling** (bottom right) (BS, electrical engineering, University of Kentucky, 1970; MS, electrical engineering, Vanderbilt University, 1975) worked in industry as a process controls designer and systems application engineer for 5 years and as a project manager for 2 years before joining LANL in 1978. Since joining LANL, he has worked in nuclear weapons at the Nevada Test Site, was channel operations manager at the Meson Physics Pion Radiotherapy Center, and did controls applications engineering in the Laser Fusion Program. Currently, he is involved

in controls applications engineering and system modeling on the ion injector for the Neutral Particle Beam Accelerator. Photographs and biographies for **Michael Kang** and **Michael D. Burrows** were not available at publication time.

USE OF INCOHERENCE TO PRODUCE SMOOTH AND CONTROLLABLE IRRADIATION PROFILES WITH KrF FUSION LASERS

Robert H. Lehmberg
Julius Goldhar

Robert H. Lehmberg (top) (BS, physics, Pennsylvania State University, 1959; MS, physics, University of Arizona, 1961; PhD, physics, Brandeis University, 1968) was a research physicist at the Naval Air Development Center, Johnsville, Pennsylvania, from 1966 to 1972, working on optical data processing, electromagnetic propagation, and laser physics. Since joining the Naval Research Laboratory, Washington, D.C., in 1973, he has conducted research in laser physics, nonlinear optics, laser-plasma interactions, and laser fusion. **Julius Goldhar** [BS, Massachusetts Institute of Technology (MIT), 1971; PhD, MIT, 1976] worked at the Lawrence Livermore National Laboratory from 1976 to 1985, developing advanced lasers for laser fusion. Presently, he is an associate professor in the Department of Electrical Engineering, University of Maryland, and is conducting research in the field of high-power lasers and nonlinear optics.

KrF LASER STUDIES AT HIGH KRYPTON DENSITY

Alexander E. Mandl
Daniel E. Klimek
Edward T. Salesky

Alexander E. Mandl (top) (BS, physics, City College of New York, 1960; MS, 1963, and PhD, 1967, physics, New York University) performed his postdoctoral research in electron scattering at the U.S. National Bureau of Standards. Since 1969, he has been with the Avco Research Laboratory, Inc. (ARL), where he has pursued experimental research on alkali halides, halogen negative ions, rare-gas-halide kinetics, mercury and mercury cadmium excimers, and, most recently, ultraviolet excimer laser. **Daniel E. Klimek** (center) (BS, State University of New York, Stony Brook, 1970; PhD, chemistry, University of Wisconsin, Madison, 1975) worked as a postdoctoral fellow at the University of Toronto. This research involved the study of elementary chemical reactions using molecular beam, infrared chemiluminescence, and laser-induced fluorescence techniques. He joined ARL in 1978, and has been involved with the directed energy research effort. He has worked with KrF laser kinetics (experiment and computer modeling), vapor phase and conventional dye laser development, and rotational and vibrational Raman physics. **Edward T. Salesky** (bottom) (BS, physics, Lowell Technological Institute, 1971; MS, 1976, and PhD, 1978, physics, University of Lowell) worked at ARL, from May 1972 to February 1979, in the areas of laser development (experimental and modeling) of high-power intermediate resonance (IR) (CO_2) and excimer (KrF and XeF) lasers. From March 1979 to May 1985 he worked at Los Alamos National Laboratory on the Inertial Confinement Fusion Project (CO_2 and later KrF). His contributions to these projects included laser kinetics (experimental and theoretical), laser discharge modeling, laser beam transport (angular multiplexing) high-voltage (2-MV) pulse power module development, physics of electron-beam transport, and many other system issues. He joined North East Research Associates in May 1985 as principal research scientist. His research areas involve multidimensional modeling of excimer (KrF, XeF, and XeCl) and IR (DF, CO_2) laser systems. These models include

formation kinetics, energy extraction, and laser beam propagation and interaction with the earth's atmosphere (turbulence, Raman conversion, and thermal blooming).

ATMOSPHERIC PRESSURE OPERATION OF A KrF LASER OSCILLATOR AND AMPLIFIER WITH A KRYPTON-RICH MIXTURE AND A Kr/F_2 MIXTURE

Akira Suda
Minoru Obara
Akira Noguchi

Akira Suda (top) (MS, Keio University, Japan, 1984) is a graduate student in the Department of Electrical Engineering, Keio University. His current interest is in the field of electron-beam (*e*-beam)-excited rare-gas halide lasers, halogen excimer lasers, and *e*-beam-initiated H_2/F_2 chemical lasers for inertial confinement fusion (ICF) applications. **Minoru Obara** (center) (PhD, Keio University, Japan, 1976) is an associate professor in the Department of Electrical Engineering, Keio University. He has been engaged in research on high-power pulsed gas lasers such as HF, DF, CO_2, rare-gas halide lasers, and pulsed power technologies for ICF applications. **Akira Noguchi** (bottom) (PhD, Keio University, Japan, 1969) is an associate professor in the Department of Electrical Engineering, Keio University. His research interests are nonlinear waves and inverse problems.

KrF LASER OPTIMIZATION

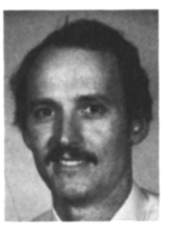
Stephen J. Czuchlewski
David E. Hanson
Burton J. Krohn
Alvin R. Larson
Edward T. Salesky

Stephen J. Czuchlewski (top right) (BS, physics, Manhattan College, 1965; PhD, Yale University, 1973) was a postdoctoral research associate at Kansas State University where he used a tandem Van de Graaff accelerator to study atomic physics phenomena in high-energy heavy ions. Since 1975 he has been a staff member at the Los Alamos National Laboratory (LANL). He has investigated the physics and kinetics of high-energy CO_2 and KrF lasers for the inertial fusion program. He has also studied pulse propagation in laser amplifiers, laser-initiated plasma breakdown processes, and saturable absorber gas isolators for high-power CO_2 lasers. He is presently working on the propagation of intense relativistic electron beams and on advanced design concepts for electron accelerators. **David E. Hanson** (top left) (BS, physics, University of Oregon, 1966; MA, physics, University of California at Santa Barbara, 1970) has performed experiments and computer modeling at Exxon Nuclear, Richland, Washington, on the uranium laser isotope program. Since 1981 he has been a staff member at LANL working on the uranium and plutonium laser isotope separation programs and on KrF lasers. **Burton J. Krohn** (bottom right) (BA, physics-astronomy, Vanderbilt University, 1964; MS, 1966, and PhD, 1971, theoretical physics, Ohio State University), in his postdoctoral research, focused on the vibrational energies and properties of polyatomic molecules at the Battelle Memorial Institute, Columbus, Ohio, 1971–72, and on interpretation of infrared spectra at the Department of Physics, Florida State University, 1973–74. In November 1974, he joined LANL, where he has provided theoretical support to numerous experiments in FT-IR and laser spectroscopy. Recently, he has also performed kinetics calculations for the development of excimer lasers. **Alvin R. Larson** (bottom left) (BS, engineering physics, South Dakota State University, 1959; MS, physics, Trinity College, 1963) has been a staff member at LANL since 1965. In 1978 he received a PhD in physics, performing his dissertation work on homogeneous nucleation theory. He has conducted research in radiation transport, fluid dynamics, inertial confinement fusion, laser-plasma interaction,

chemical kinetics, and laser physics. **Edward T. Salesky** (right) (BS, physics, Lowell Technological Institute, 1971; MS, 1976, and PhD, 1978, physics, University of Lowell), in his master's thesis, treated the problem of laser beam propagation through the turbulent atmosphere. His doctoral thesis considered the problem of spectral line broadening and shift due to atomic and molecular interactions. He worked at Avco Everett Research Laboratory from May 1972 to February 1979. His areas of research included laser development (experimental and modeling) of high-power IR (CO_2) and excimer (KrF and XeF) lasers. From March 1979 to May 1985, he worked at LANL on the inertial confinement fusion project (CO_2 and later KrF). His contributions to these projects included laser kinetics (experimental and theoretical), laser discharge modeling, laser beam transport (angular multiplexing) high-voltage (2-MV) pulse power module development, physics of electron-beam transport, and many other system issues. He joined North East Research Associates (NERA) in May 1985 as principal research scientist. His research areas involve multidimensional modeling of excimer (KrF, XeF, and XeCl) and IR (DF, CO_2) laser systems. These models include formation kinetics, energy extraction, and laser beam propagation and interaction with the earth's atmosphere (turbulence, Raman conversion, and thermal blooming).

ELECTRON-BEAM SOURCES FOR PUMPING LARGE APERTURE KrF LASERS

Louis A. Rosocha
Kenneth Bruce Riepe



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AURORA INERTIAL CONFINEMENT FUSION LASER CONTROL AND DATA ACQUISITION SYSTEM

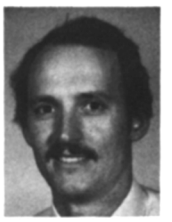
P. Stuart Bowling
L. Burczyk
R. D. Dingler
R. B. Shurter

P. Stuart Bowling (right) (BS, electrical engineering, University of Kentucky, 1970; MS, electrical engineering, Vanderbilt Univesity, 1975) worked in industry as a process controls designer and systems application engineer for 5 years and as a project manager for 2 years before joining the Los Alamos National Laboratory (LANL) in 1978. Since joining LANL, he has worked

in nuclear weapons at the Nevada Test Site, was channel operations manager at the Meson Physics Pion Radiotherapy Center, and did controls applications engineering in the Laser Fusion Program. Currently, he is involved in controls applications engineering and system modeling on the ion injector for the Neutral Particle Beam Accelerator. Photographs and biographies for **L. Burczyk**, **R. D. Dingier**, and **R. B. Shurter** were not available at publication time.

BEAM PROPAGATION CONSIDERATIONS IN THE AURORA LASER SYSTEM

Louis A. Rosocha
John McLeod
John A. Hanlon



Louis A. Rosocha (top) (BS, physics, University of Arkansas–Fayetteville, 1972; MS, 1974, and PhD, 1979, physics, University of Wisconsin–Madison), in his dissertation, researched experimental and theoretical investigations of the plasma chemistry of transient electrical discharges in oxygen, the associated production of ozone, and the application of relativistic electron-beam physics and pulsed power technology to the excitation of proposed liquid excimer lasers. While finishing his doctoral work, he joined the National Research Group in Madison, Wisconsin, where he was involved in research, development, and manufacturing related to pulsed ultraviolet and dye lasers, high-voltage switches, and ozone generators. In 1981, he joined Los Alamos National Laboratory (LANL), where he served as a staff physicist, technical manager, and assistant test director on the Antares CO_2 and Aurora KrF inertial confinement fusion (ICF) projects. In 1984, Rosocha was appointed project manager for the Aurora project. On this project, he is in charge of the overall design, construction, and testing activities necessary to build a multikilojoule angular-multiplexed KrF laser system prototype for inertial fusion. In addition, he currently serves as the acting deputy group leader for the pulsed power systems group at LANL. **John McLeod** (center) (Harvard College, 1954; PhD, physics, Princeton University, 1962) joined LANL in March 1960. He has participated in programs in space nuclear propulsion, magnetic confinement fusion, and ICF. His primary role in the ICF program has been development of laser drivers, including Nd:glass, carbon dioxide, and krypton fluoride. **John A. Hanlon** (bottom) (BS, 1959, and MS, 1961, electrical engineering, University of Nebraska; PhD, electrical engineering, University of Arizona, Tucson, 1970) has been a staff member at LANL since 1977. He has participated as an optical engineer on the Helios and now the Aurora laser fusion programs. Prior to coming to LANL he did research and development on optical resonators as a civilian at the Air Force Weapons Laboratory in Albuquerque, New Mexico.

THE AURORA LASER OPTICAL SYSTEM

John A. Hanlon
John McLeod

John A. Hanlon (top) (BS, 1959, and MS, 1961, electrical engineering, University of Nebraska; PhD, electrical engineering, University of Arizona, Tucson, 1970) has been a staff member at Los Alamos National Laboratory (LANL) since 1977. He has participated as an optical engineer on the Helios and the Aurora laser fusion programs. Prior to coming to LANL, he did research and development on optical resonators as a civilian at the Air Force Weapons Laboratory in Albuquerque, New Mexico. **John McLeod** (Harvard College, 1954; PhD, physics, Princeton University, 1962) joined LANL in March 1960. He has participated in programs in space nuclear propulsion, magnetic confinement

fusion, and inertial confinement fusion (ICF). His primary role in the ICF program has been development of laser drivers, including Nd:glass, carbon dioxide, and krypton fluoride.

OUTPUT OPTICS FOR AURORA: BEAM SEPARATION, PULSE STACKING, AND TARGET FOCUSING

John McLeod

John McLeod (Harvard College, 1954; PhD, physics, Princeton University, 1962) joined Los Alamos National Laboratory in March 1960. He has participated in programs in space nuclear propulsion, magnetic confinement fusion, and inertial confinement fusion (ICF). His primary role in the ICF program has been development of laser drivers, including Nd:glass, carbon dioxide, and krypton fluoride.

PAC-MAN, A PRECISION ALIGNMENT CONTROL SYSTEM FOR MULTIPLE LASER BEAMS SELF-ADAPTIVE THROUGH THE USE OF NOISE

Birchard L. Kortegaard

Birchard L. Kortegaard (BSEE, Massachusetts Institute of Technology; MSEE, University of California, Berkeley) is a project engineer for the HILAC and also the SUPERHILAC at Berkeley. He is an engineering consultant for ASTRON at Lawrence Livermore National Laboratory and for the accelerator at Darmstadt, Federal Republic of Germany. He is section leader for three major laser systems at Los Alamos National Laboratory and a winner of a 1985 distinguished performance award. The work in this paper won a 1986 IR-100 award.

DESIGN OF A 100-kJ KrF POWER AMPLIFIER MODULE

J. Allan Sullivan

J. Allan Sullivan (BS and MS, aeronautical engineering, University of Colorado; PhD, mechanical engineering, University of Michigan) joined Los Alamos National Laboratory (LANL) in 1966. In his first few years with LANL he worked on advanced nuclear reactor concepts and computer codes for transient reactor behavior. In association with C. P. Robinson, he helped pioneer some of the early research in laser development and isotope separation. In 1974 he was appointed group leader of the laser isotope separation engineering group in the Applied Photochemistry Division. This group worked on advanced engineering for the then fledgling molecular laser isotope separation program. In 1977 he served as the alternate director for the Reactor Behavior Division of EG&G Idaho, Inc., Idaho Falls, and then returned to LANL's Applied Photochemistry Division where he served as a project leader for novel instrumentation applications of lasers and as an industrial liaison officer. In 1980 he was assigned to the U.S. Department of Energy's Office of Advanced Isotope Separation where he represented LANL's interests in formulating the criteria for deciding which advanced isotope separation technology would be scaled to production facilities. After he returned to LANL, he assumed the position of program manager for the engineering implementation of molecular laser isotope separation. From mid-1982 through mid-1983 he served as an assistant to the deputy associate director for nuclear programs. In 1983 he joined the Physics Division at LANL and was principally responsible for managing the scaling of KrF lasers to 100-kJ class devices.

FUTURE DEVELOPMENTS AND APPLICATIONS OF KrF LASER-FUSION SYSTEMS

David B. Harris
Norman A. Kurnit
Dennis D. Lowenthal
Russell G. Berger
John M. Eggleston
James J. Ewing
Mark J. Kushner
Lester M. Waganer
David A. Bowers
David S. Zuckerman

David B. Harris (top) (BS, 1978; MS, 1982; and PhD, 1984, nuclear engineering, University of Illinois) joined Los Alamos National Laboratory (LANL) in 1984 as a staff member of the Energy Systems Engineering Group in the Analysis and Assessment Division. His current work involves systems analysis for KrF laser-fusion drivers, inertial confinement fusion (ICF) targets, and ICF reactor systems. **Norman A. Kurnit** (center) (AB, Columbia College, 1961; MA, 1962, and PhD, 1966, physics, Columbia University), whose thesis research resulted in the first observation of photon echoes and their application to the study of relaxation processes in ruby, remained at Columbia as a research associate and instructor until 1968, when he joined the Optical and Infrared Laser Laboratory at the Massachusetts Institute of Technology (MIT) as a research associate. At MIT, where he served as assistant professor of physics from 1969 to 1975, his research interests included other coherent transient phenomena, as well as the application of continuous wave nonlinear saturation techniques to the study of molecular relaxation processes and to laser stabilization and precision wavelength measurement. In 1975 he became a staff member at LANL, where he has worked on applications of Raman and Brillouin scattering, four-wave mixing, and phase conjugation, primarily for CO_2 and excimer laser development. **Dennis D. Lowenthal** (photo not available) [BS, physics, California State University, Northridge, 1965; MS, physics, University of California, Los Angeles (UCLA), 1966; PhD, physics, University of California, Irvine, 1975], whose dissertation work included an experimental search for double beta decay in ^{82}Se using a cloud chamber and low-background counting techniques, joined Ford Aerospace in Newport Beach, California, in 1966, where he contributed to a number of geometrical and physical optics studies. Since 1975, he has been with Spectra Technology Inc. (STI) (formerly Mathematical Sciences Northwest) in Bellevue, Washington. At STI his primary interests have been laser system design, analysis, and optimization. This work has included KrF lasers for fusion, laser systems for isotope separation, and lasers for particle acceleration. Most recently, he has contributed technically and served as program manager for a variety of programs. These include a delivered turnkey CO_2 laser to the Lawrence Livermore National Laboratory (LLNL) for their Paladin FEL program and the construction of a vacuum ultraviolet laser system at STI for Sandia National Laboratories (SNL). **Russell G. Berger** (photo not available) (BS, applied mathematics, engineering, and physics, University of Wisconsin–Madison, 1977; MS, physics, University of Washington, Seattle, 1982) performed, from 1982 until 1985, experimental research on laser-plasma interactions at the University of Washington. Since 1985 he has been a scientist at STI, where he has worked on modeling Raman laser beam combining systems, studies of laser particle accelerator concepts, and analysis of CO_2 and free electron lasers. **John M. Eggleston** (bottom) (BA, electrical engineering, Rice University, 1976; PhD, applied physics, Stanford University, 1983), in his dissertation work, included experimental and theoretical studies of slab geometry, solid state lasers and theoretical analysis of broad-band Raman shifting. Since January 1982, he has been with STI, where he has continued development of Nd:YAG and Nd:glass slab geometry laser systems and has been pursuing the development of Ti:sapphire as a turnable laser system. He has been active in optical modeling, analysis and development of large laser systems, KrF laser fusion systems, and FEL lasers. He has continued his work in Raman shifting to include multiple pump beams and is pursuing other areas of nonlinear optics.

James J. Ewing (top right) (BA, University of California, Riverside, 1964; PhD, physical chemistry, University of Chicago, 1969), in his doctoral thesis, studied nonequilibrium effects in the dissociation of alkali halides. He has served as a chemistry department faculty member at both the University of Illinois and the University of Delaware. At AVCO Everett Research Laboratory from 1972 to 1976, he performed pioneering work on excimer kinetics and spectroscopy, which led to the first demonstration by him of lasing action on XeF, XeCl, KrF, and I_2 lasers in the ultraviolet (UV), and discharge excitation of the Br_2 laser. This work led to a true scientific revolution in UV laser sources for defense, energy, commercial, and industrial applications. From 1976 to 1979, Ewing was at LLNL, where he was program manager for the advanced excimer fusion laser technology test bed, RAPIER. He joined STI as director of laser technology in 1979 and was promoted to vice-president of laser programs in 1982. He has overall responsibility for managing and directing STI's laser research and development business. This work includes pioneering the development of free-electron lasers, gas discharge lasers for laser radar applications, high-power solid-state laser, tunable solid-state lasers, efficient electron-beam-pumped excimer lasers, short wavelength drivers for ICF, high-PRF commercial prototype excimer lasers, laser and plasma chemistry applications, and pulsed power component development. **Mark J. Kushner** (top left) (BS, nuclear engineering, and BA, astronomy, UCLA, 1976; MS, 1977, and PhD, 1979, applied physics, California Institute of Technology) served on the technical staffs of SNL and LLNL, and served as director of electron, atomic, and molecular physics at STI. In August 1986, he joined the faculty of the electrical and computer engineering department at the University of Illinois (Urbana-Champaign). He has conducted research on various topics in the fields of gaseous electronics, laser physics, pulsed power plasmas, plasma processing of semiconductors, and nonlinear optics. **Lester M. Waganer** (center right) (MS, mechanical engineering, University of Missouri, 1963) has been with McDonnell Douglas Astronautics Company (MDAC), St. Louis, Missouri, since 1970. He is currently project manager on the EPRI/LANL/LLNL heavy-ion fusion systems assessment project and the LANL inertial fusion systems studies project and systems integration manager for the LANL Bear I neutral particle beam experiment. He was the project leader on an Electric Power Research Institute (EPRI) project to assess the technical risks of developing a deuterium-tritium fuel system for a commercial fusion power plant. Previously, he was the project engineer on the Elmo Bumpy Torus (EBT) reactor and power plant conceptual design study for LANL and was in charge of project engineering and systems analysis activities for the STARFIRE reactor design study. **David A. Bowers** (bottom left) (BS, mechanical engineering, Purdue University, 1965) has been the senior thermal-hydraulics analyst on the MDAC fusion energy staff since 1975. His primary interests have included the thermal analysis and design of various fusion devices and components, including vacuum vessel walls, limiters, antennas, Faraday shields, armor, neutral beam components, and other structural parts. He supervised thermal support for the EBT proof-of-principle project at MDAC. **David S. Zuckerman** (bottom right) (MS, mechanical engineering, Washington University, 1982) has been working in systems integration at MDAC since 1977. His primary work has been in the areas of fusion power plant modeling and technology forecasting. He has been responsible for the creation of a number of commercial fusion power plant computer simulations involving the integration of physics, engineering, and cost algorithms. He has also had a primary role in the development of methods for forecasting future performance of fusion components and other new technologies.

IMPROVING INERTIAL CONFINEMENT FUSION POWER PLANT AND EFFECTIVE DRIVER EFFICIENCIES BY GENERATING ELECTRICITY FROM KrF LASER REJECT HEAT

John H. Pendergrass

John H. Pendergrass (BA, 1962, and BS, 1963, chemical engineering, Rice University; PhD, chemical engineering, Cornell University, 1975) is a senior staff member at Los Alamos National Laboratory. He has worked on many aspects of inertial confinement fusion systems and applications studies, including experimental and commercial driver, reactor, and power plant conceptual designs, cost and economic studies, research and development program planning, and alternative applications studies. Other activities included advanced isotope separation, synthetic fuels, and defense systems studies.