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Materials and Molecular Research Division

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Volume 3, No. 4

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**FINNIE AND PRAUSNITZ ELECTED TO NAE**

Professors IAIN FINNIE and JOHN PRAUSNITZ have been elected to the National Academy of Engineering. Election to the NAE is considered the highest professional distinction that can be given an engineer.

The NAE is a private organization established in 1964 to share in the responsibility given the National Academy of Sciences under its Congressional Charter of 1863, and to examine questions of science and technology at the request of the federal government.

FINNIE's work in high-temperature design, erosion, and brittle fracture of materials is internationally known. Besides publishing more than 90 technical papers and jointly authoring a book, "Creep of Engineering Materials," he is a Professor of Mechanical Engineering at UCB and works with the LEVY Group at MMRD on solid particle erosion corrosion problems of coal conversion processes. He is also

(Continued on page 3)

PRAUSNITZ

Prof. JOHN PRAUSNITZ has just added another outstanding achievement to an uncommonly fine collection of awards and honors; he has been elected to the NAE while already a member of the National Academy of Sciences! Very few indeed, are the persons who can claim election to both of these distinguished organizations.

PRAUSNITZ, an investigator with MMRD as well as a Professor of

(Continued on page 3)

RESEARCH PROFILE

HIGH-TEMPERATURE CORROSION

D. P. Whittle

Because metals occur in nature as oxide and sulfide ores, considerable energy and money must be expended to extract them. Ironically, conditions inside many advanced energy production and conversion units can reverse the reaction and, through corrosion, return the metals to their native forms.

Resistance to corrosive environments at high temperatures, then, has become an absolute requirement for materials, especially for those used in advanced gas turbine engines; coal combustion, gasification, and liquefaction systems; and high-temperature reactors. Of course, corrosion resistance is not the only requirement: strength, workability, and economic factors are all important. But the main objective of our research programs is to gain insight into why corrosion occurs and how it can be prevented.

How, then, do we go about providing oxidation resistance? If an alloy is to resist oxidation, it must form a protective oxide scale on its surface; the scale then acts as a barrier that minimizes further interaction with the environment. By "protective" we mean two things. First, transport of reacting ions through the oxide must be slow. Most oxides are non-stoichiometric and contain defects: vacant sites in either, or both, cation and anion sub-lattices permitting lattice transport, or more extended defects, such as sub-grain and grain boundaries acting as short-circuit diffusion paths. In addition, if the protective scale is to function as an effective barrier, it must remain adhered to the alloy and the detailed morphology of the alloy/scale interface is critical.

(Continued on page 6)

MMRD HELPED CONTROL THE THREE MILE ISLAND REACTOR ACCIDENT!

Early Saturday morning, March 31, Dr. HEINZ HEINEMANN received a call from Bob Budnitz of the Nuclear Regulatory Agency (NRC) at his home. The NRC needed help in locating some specialized petroleum industry equipment needed to reach inside the malfunctioning reactor.

Later in the day when it had been established that a hydrogen bubble of some 12,000 cubic feet had formed in the reactor, a series of telephone consultations began between Professors DAVID SHIRLEY, LEO BREWER, GABOR SOMORJAI and Dr. HEINEMANN and Dr. Paul Bryant of Combustion Engineering who was coordinating chemical efforts from Connecticut. Various catalytic ideas were discussed and evaluated by the scientists who eventually did eliminate the dangerous bubble and began cooling the reactor.

In the aftermath of the confusion and worry which accompanied the often contradictory news reports of the reactor accident, it is comforting to know the reactor operators and regulators involved immediately contacted outstanding scientists across the country for advice and assistance in handling the unique crisis. Just knowing such a network of talent, brain-power, and experience can be quickly mobilized to focus on such a hazard reduces both the danger itself and the fear that laymen have for the complexities of nuclear reactor safety control.

REACTORS MADE EASY or AD-ING FEAR TO NUCLEAR POWER!

"Nuclear Reactor Plant Operator; No Experience Necessary; Must be a high school diploma (sic) graduate 17 to 24 with at least a C average in Algebra. Full pay while training."

Dr. David M. Clark of Greensboro, NC discovered the above ad. "No wonder the Anti-Nukes worry so much!" ... from letter section of C&E News.

FINNIE (Continued)

the Technical Editor of the Journal of Engineering Materials and Technology of ASME.

IAIN was born in Hong Kong, but is of Scottish background. In fact, he attended the University of Glasgow (B.Sc., 1949) and went on to graduate training at MIT where he obtained his MS, ME, and Sc.D. In 1953 he came to California to join Shell Development Company in Emeryville and from there joined the staff of the Mechanical Engineering Department at UCB in 1961.

In 1965 he served for a while as a visiting professor at the Catholic University of Chile. He received a Guggenheim Fellowship in 1967-68 and has served as Vice-Chairman of the Department of Mechanical Engineering.

It is obvious that Prof. FINNIE is a very busy man--in fact, his phone rang with disconcerting frequency during the interview, but he remained unflustered by all the activity surrounding him, and reacted with pleased delight when tossed an unanticipated question.

He learned of the honor when he picked up his mail one afternoon and noticed a manila envelope from Washington in the pile. He quickly stuffed it all in his briefcase to check at home later figuring it was just more junk mail such as arrives daily. Working quickly through the stack, he reached the manila envelope, opened it, gulped then reread it again before it finally registered. When his students learned of the honor, they arranged a party to celebrate.

IAIN is married, has three daughters 16, 14, and 7, and likes skiing and gardening. In fact the two older girls were in Utah just recently on a ski trip, "but," says IAIN, "it's my youngest who is most likely to show an interest in engineering--

she loves numbers and enjoys tinkering with toys and mechanical gadgets."

Although his first publication was "A Guide to Boston's Restaurants," FINNIE is not an authority on Bay Area foodspots. Why? Well, his wife Joan is such a fine cook (she teaches a class in cooking) he'd rather eat home!

"What event in the entire history of engineering would you most like to be present at if that were possible, IAIN?"

"Dedication of the first commercial fusion reactor!"

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PRAUSNITZ (Continued)

Chemical Engineering at UCB, was cited for his contributions to the thermodynamics of phase equilibria and its application to industrial process design.

JOHN received his BChE from Cornell University in 1950; M.S. from the University of Rochester in 1951; and Ph.D. at Princeton University in 1955. He joined the Berkeley faculty that same year and has been a professor since 1963.

Among the awards and honors accumulated by Prof. PRAUSNITZ are two Guggenheims, two Miller Research Professorships, the Colburn Award, and the Walker Award of AIChE, the Alexander von Humboldt Senior U.S. Scientist Award, and the E. V. Murphree Award for 1978.

With such a notable collection of honors, it seemed reasonable to assume JOHN would know well how to celebrate fittingly on this new occasion. He did!

----"With French Champagne!"

WANG, PICKUS, CHEN GRANTED PATENT

A United States patent entitled, "Copper-Base Alloy for Liquid Phase Sintering of Ferrous Powders" has been granted to MMRD/LBL researchers JOHN LING-FAI WANG, MILTON R. PICKUS, and MENG-HSIU CHEN, a former graduate student here. Patent number 4,130,422 was published in the Official Gazette of the Patent Office on December 19, 1978.

This invention provides an exciting new approach to the long-known technology of mixing iron and copper powder to produce high-strength steel materials. By using an intermetallic powder compound of copper, manganese, and silicon (CuMnSi) mixed with the iron, a liquid phase is achieved in the sintering of the iron. (Sintering is a process for forming a coherent bonded mass by heating metal powders without melting.)

The liquid phase occurs when the newly patented CuMnSi powder melts (780°C) and wets the iron particles by rapidly spreading over their surfaces reducing the diffusion distance to provide a more homogeneous mass. During this liquid phase of the homogenizing heat treatment, both silicon and manganese are preferentially diffused into the iron particles, strengthening them and leaving behind a ductile copper alloy to serve as a binder.

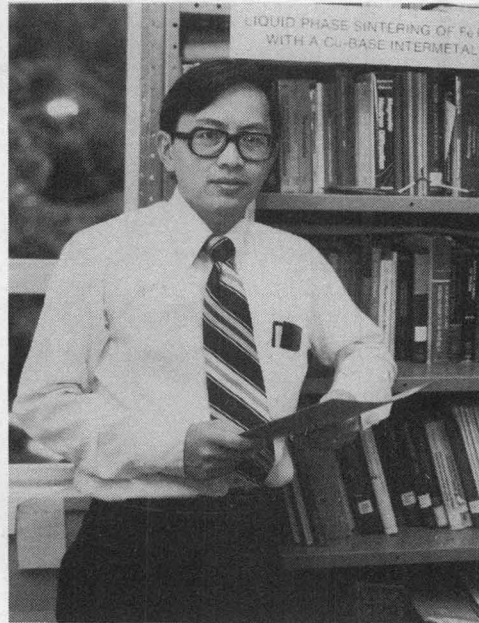
Tests show that by simply pressing and sintering the powder blend of the iron particles with the powdered CuMnSi intermetallic compound, densities over 98% of theoretical and tensile strengths of 100 KSI may be obtained.

The powder processing route is now recognized and respected as a competitive technology and an alternative to existing, conventional metal forming. Potential has also given way to proven capability for production of new and unusual materials, especially important

in automobile manufacturing, domestic equipment components, and business machines.

The patent, assigned to the U.S. Department of Energy, has also been filed in the United Kingdom, France, West Germany, Sweden, Japan and Canada.

❖



FIVE FOR WANG!

Well-known MMRDer JOHN LING-FAI WANG, had no idea when he learned English in junior high and high school in Hong Kong, that that beginning would eventually lead him to Hop College in Holland, Michigan! With even more wonder he recalls developing an interest in science while still in junior high by reading about Ernest O. Lawrence and his research in atomic physics and now finds himself researching and assisting several graduate research projects here in that same laboratory.

JOHN was born in Amoy in southern China. After the family moved to Hong Kong where his father was a successful businessman, JOHN and

(Continued on page 5)

WANG (Continued)

his older brother learned English and, responsive to their father's desire they become scholars instead of joining in his business, both attended Hope College. LING-CHI, the older brother studied music, philosophy and history and is now teaching in the Asian-American Studies Department on campus. JOHN LING-FAI took his degree in Chemistry in 1965, then followed graduate work as a Research Assistant with Prof. LEO BREWER and obtained his Ph.D. in Chemistry in 1969.

JOHN worked one year with Prof. ALAN W. SEARCY, then did more post-doctoral work at Rice University in Houston with Prof. J. L. Franklin and Prof. J. L. Margrave and returned to rejoin Prof. BREWER briefly before becoming part of the PICKUS Research Group on inter-metallic compounds, liquid phase sintering and superconductors.

During the course of his work with the PICKUS Group, WANG has his name attached to five invention disclosures.

JOHN, whose main interest is science, is a member of several professional societies, as well as Sigma Xi and the Blue Key National Honor Fraternity. In addition, he remains an avid soccer player and maintains his interest in a stamp collection he started as a small boy in Hong Kong.

"QUOTE"

"There's always been a grudging minority in Washington whose steady belief has been that if the government shuts down, no one would miss it. Now after three (snow) days with virtually no federal, city or regional bureaucracies, it can be reported that it's true. The government shut down and nothing happened." -- The Washington Star

MINI-GRANTS AVAILABLE AT UCB

Faculty members, students and teaching assistants are invited by the Academic Senate Committee on Teaching to apply for mini-grants designed to improve instruction, assess curriculum, evaluate teaching effectiveness or otherwise upgrade the instruction in one or all of your courses. Proposals for the Summer and/or Fall Quarter 1979 are due Friday, May 4th. Application forms and assistance in designing a project can be obtained from

Teaching Innovation and
Evaluation Services (YIES)
262 Stephens Hall
Campus ph. 682-1811

Recently Professor WILLIAM JOLLY obtained a lap-dissolve attachment for use with two slide projectors. This allows the image to be slowly and smoothly brightened on one projector while dimming on the other giving an illusion of motion to the presentation. Professor JOLLY used the mini-grant program to obtain the equipment for this system. "I think this technique will greatly help students who have difficulty visualizing in three dimension," explains Professor JOLLY.

NOSE FOR NEWS?

Any activity (lecture, promotion, award, membership, etc.) which will be included in the biography section of your bio-bib should be immediately forwarded to your editors for possible use in the Newsletter. If everyone helps, we'll give public recognition to your achievements and also be able to keep improving the accuracy, quality, and completeness of the NEWLETTER.

It is your NEWSLETTER--so KEEP US INFORMED!

RESEARCH PROFILE (continued)

All high-temperature alloys--stainless steels, nickel and cobalt-base superalloys--and protective coatings contain sufficient chromium and/or aluminum to form surface scales of Cr_2O_3 or Al_2O_3 . These are the prime protective oxides. They contain relatively few defects and consequently thicken slowly.

There are problems with their adherence to the substrate, however, particularly when they are subjected to thermal cycling or to other mechanical shocks. Deterioration and loss of the Al-rich coatings protecting aero-gas turbine blading is primarily through spallation of the Al_2O_3 scale. The adherence can be improved by adding active elements--Y, La, Ce and the like--or dispersed oxide phases. In one aspect of our current program we are examining the adherence problem in more detail. We have shown that a critical factor is modification of the alloy/scale interface by the formation of inward-growing pegs of oxide which key the surface scale to the alloy. These pegs form around particles of active element oxides with the incoherent interface between dispersed phase and matrix acting as an easy transport path.

Figure 1 compares the underside of the Al_2O_3 scale stripped from CoCrAl alloys containing (a) Hf and (b) Hf, converted to oxide dispersion by a pre-internal oxidation treatment. A fine, uniform distribution of oxide pegs seems to be optimal; that is, (b) is better than (a). Uniform distribution of the oxide pegs is difficult to control in the case of metallic additions, however, because the active element virtually oxidizes internally during high-temperature exposure. Moreover, these internally-precipitated oxides form the nuclei about which the protective oxide forms the pegs. Clearly, the distribution of internal oxides, and subsequently the pegs, depends on the exposure conditions and is thus

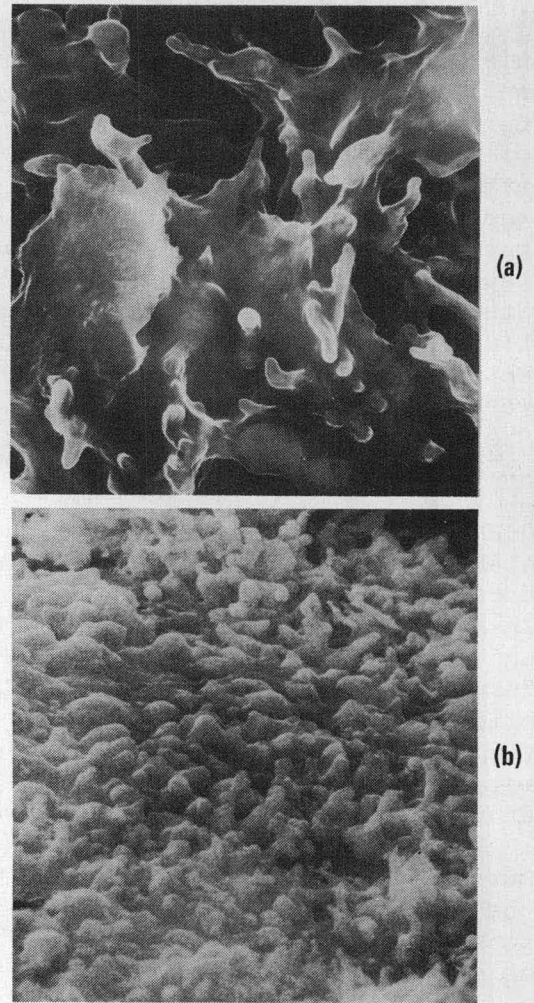


Fig. 1. Underside of the Al_2O_3 scale stripped from Co-10Cr-11Al-Hf oxidized for 1000 hr at 1200°C : (a) no internal oxidation treatment; (b) sample given a pre-internal oxidation treatment of 200 hr at 1200°C .

not directly controllable. Although not very practical, a pre-internal oxidation treatment is one way of controlling the oxide, and hence the peg, dispersion. Other methods, which can be applied simultaneously with a conventional coating process, such as aluminizing, are being sought. In addition, the nature of the dispersed phase does not seem critical so stable phases, such as nitrides and intermetallics, are being tried. The possibility of chemical effects modifying the bond between oxide and substrate is also being considered.

RESEARCH PROFILE (continued)

Thus far we have seen that, given a "clean" high-temperature environment and an alloy that can develop an adherent Al_2O_3 or Cr_2O_3 scale, oxidation resistance should be ensured. But nature is not so accommodating. Virtually all fossil fuels contain sulfur as an impurity and when they are burned--whether in a turbine, in fluidized beds, or in conversion processes, such as coal gasification or liquefaction--they generate atmospheres that contain sulfur compounds. In turn, the sulfur compounds can lead to sulfidation problems; and formation of metal sulfides always accelerates the rate of material degradation. Sulfur competes with oxygen for the principal scale-forming elements, Cr and Al, thereby interfering with the process of protective scale formation; and because sulfides are far more defective than corresponding oxides, they thicken more rapidly. In addition, the very low oxygen potentials encountered in environments associated with energy conversion can inhibit the formation of protective oxide scales. Indeed, the whole concept of relying on an oxide scale for corrosion protection may no longer be valid in such systems, and a new rationale on which to base alloy design for high-temperature corrosion resistance may be necessary. Both the fundamental and the practical aspects of material degradation in these high-temperature, aggressive environments form the major part of our research program.

Figure 2 is a schematic metal-sulfide-oxide stability diagram. The regions--as a function of oxygen and sulfur potential--where metal sulfide or oxide are stable are outlined. First, consider gaseous atmospheres corresponding to the shaded area (as in A); such atmospheres are typical of coal conversion, in which the oxygen activity is high enough to form

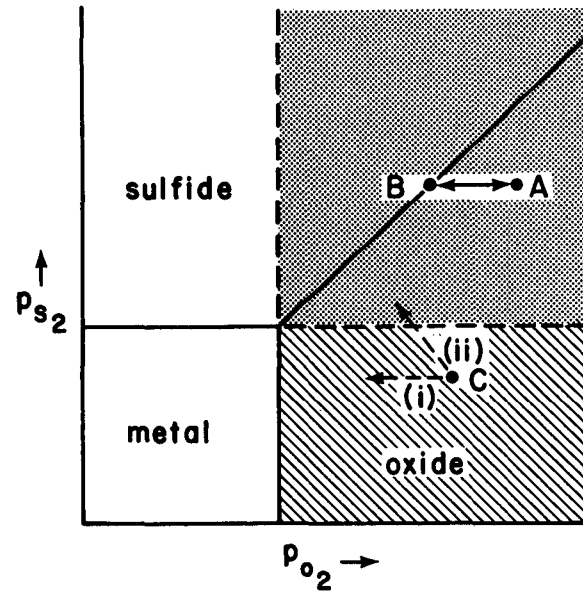


Fig. 2. Schematic M-S-O stability diagram showing the areas of activities referred to in the text.

the oxide, and the sulfur potential is high enough to form the sulfide.

In general, the atmosphere will have oxygen and sulfur potentials that will support either, but not both, oxide or sulfide formation (to the right or left of the oxide/sulfide co-existence line, respectively). Joint formation of oxide and sulfur in equilibrium with the atmosphere demands a unique gas composition (corresponding to the co-existence line).

There are other conditions, however, under which sulfide and oxide can form together at the scale/gas interface. For example, localized changes in gas composition, due to restricted access, can occur and acts to shift the composition to point B. Such conditions can exist under ash deposits in coal-fired utilities; rate-limiting diffusion in the gas phase is also a possibility.

The formation of sulfides within or below the oxide scale is more common. The obvious conclusion is that sulfur can penetrate growing

RESEARCH PROFILE (continued)

oxide layers, and that it might be over optimistic to depend simply on oxide layers for protection from sulfidation under conditions in which a conjoint attack is possible. Two possibilities present themselves: dissolution followed by lattice diffusion; and transport of gaseous molecules via physical defects, such as pores and microcracks. These are alternative and parallel mechanisms and may operate together. A gas composition such as that at point C in Fig. 2, (now in the hatched area) is typical of a process atmosphere from a low-sulfur fuel. Sulfide formation cannot be produced in such an atmosphere if sulfur dissolves in the oxide and transports to the metal/scale interface. There is no mechanism by which the sulfur activity can be increased [path (i) in Fig. 2].

If, for example, SO_2 molecules can penetrate the scale through microcracks or other physical defects, however, then changes in gas composition within the restricted volume of the crack or pore can occur. Effectively, removal of oxygen to form oxides increases the sulfur potential to the point at which sulfide may be formed [path (ii)]. The effective gas composition within the porous scale moves from the cross-hatched area into the shaded area (Fig. 2). Here differences are expected between the combusted and processed atmospheres. In the combusted atmosphere, sulfur is present mainly as SO_2 . Consequently, the sulfur potential is closely linked to the oxygen potential through the SO_2 decomposition equilibrium. In processed atmospheres, in which there are significant concentrations of hydrogen, the sulfur is present as H_2S and its potential is virtually independent of the oxygen potential. Corrosion chemistries in these two types of environments are being studied using equilibrated gas mix-

tures to control the oxygen and sulfur potentials.

Dissolved sulfur in the oxide may increase the transport of metallic ions (or oxide ions, or both) through the oxide lattice, by changing the defect structure. Our TGA measurements of the stoichiometry of Cr_2O_3 and other oxides are planned to establish that transport as a function of sulfur potential. Formation of connected networks of sulfide, which provide rapid transport paths through the oxide scale and thus short-circuit the lattice, is also being studied, particularly in the early stages of reaction where competitive nucleation is involved.

Corrosion by sulfatic deposits is another important factor that is being studied. Gas turbines in service near the ocean ingest an aerosol of seawater which can deposit thin, fused salt films of alkali sulfate and chloride onto high-temperature hardware. Deposits in coal-utilizing systems are more complex, but again sulfates are involved. In fluidized bed combustion, for example, sulfur is retained in the bed by reaction with calcined dolomite or limestone added to the bed as a sorbent, with the spent acceptor, primarily CaSO_4 , depositing on in-bed steam-raising tubes. Sulfatic deposits of this type give rise to hot corrosion, again involving sulfidation.

One function of the salt deposit is to fix the reaction potentials of sulfur and oxygen in much the same way that the interrelated gas equilibria do. However, there are additional possibilities: mechanistic interpretations of these hot corrosion phenomena involve the possibility of direct reaction between the salt and the protective oxide. Salt chemistries typical of turbine and fluidized bed combustors are being examined.

Thus, sulfide formation and its effect on the mechanism(s) of

RESEARCH PROFILE (continued)

material degradation are the keys to corrosion problems in many practical energy-related systems. The ultimate aim is (1) to relate mechanisms of behavior to the thermodynamic, diffusional, structural, and compositional parameters of the metal oxides, sulfides, and other phases involved; and (2) to develop predictive alloy corrosion models that can provide a sound technical basis for the use of existing materials and for the design of specialty alloys and coatings for particular high-temperature environments.

GARETH THOMAS presented an invited paper on "Developments in Strong, Ductile, Duplex Steels," at the Symposium on HSLA Steels at the Annual AIME Conference in New Orleans in February.

Later, during the awards banquet on the 20th, THOMAS was inducted officially as a Fellow of the Metallurgical Society and Dr. RON GRONSKY received the Hardy Gold Medal.

Dr. GRONSKY, C. K. WU, and K. KUBARYCH, all of Professor THOMAS' Research Group, also presented papers at the New Orleans Conference.

❖

PEOPLE NEWS

JOEL GARBOW, a grad student with Prof. PINES and an MMRDer, won one of the seven awards for Teaching Assistants given this year by the Chemistry Department of UCB. Congratulations, JOEL! Nice teaching.

❖

LEARR IRVIN has completed her third anniversary with the MMRD administrative staff. Seems like you just got here LEARR!

❖

Professor GARETH THOMAS, way back in 1963, presented the first graduate course at Stanford University on electron microscopy. Now, 16 years later (and after considerable teasing from Prof. THOMAS over the restrained pace by Stanford toward a microscopy facility of their own) GARETH gave the keynote lecture, March 2, 1979, which highlighted a Symposium to open their Electron Microscopy Facilities. The lecture was entitled, "Contemporary Electron Microscopy."

The Berkeley influence continues, however, as Prof. ROBERT SINCLAIR is at the helm of the Stanford program. BOB, of course, was at Berkeley from 1973-1976.

VOODARAHALLI K. NAGESH, graduate student in MS&ME, and an MMRD researcher under the late Dr. FULRATH, has received a co-grant of Patent #4,130,671, "Method for Preparing a Thick Film Conductor." A detailed story of the patent, its value, and of researcher NAGESH will be in our next issue. Congratulations, NAGESH!

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ROBERT BELLMAN, with the LEVY group, traveled to Goldendale, for the recent solar eclipse. He got some great shots, including solar prominences, using a 400mm lens. He has shown his slides to several people on request and will soon have some enlargements posted for public viewing here in Bldg. 62.

❖

Prof. D.R. OLANDER presented a seminar entitled "Uranium Enrichment by the Gas Centrifuge Method" to the Nuclear Engineering Department of MIT, March 19th.

"QUOTE"

"THE POWER OF REMEMBERING MAY BE A GIFT, BUT THE POWER TO FORGET IS A BLESSING! -- D. D. Runes

LBL REPORTS BY MMRD PERSONNEL

NOTE: All MMRD/LBL reports listed here are available in the reference section of the MMRD Library, Bldg. 62, Rm. 339, or call Marianne Larsen, Librarian, at Ext. 5971 (p.m. only)

- LBL-5753: Electron Spin Resonance Study of the Radical Anions of Substituted Cyclooctatetraenes. The Effects of Jahn-Teller Distortions and Vibronic Mixing ... *J. H. Hammons, M. Bernstein, and R. J. Myers.*
- LBL-6282: Modeling of the Electro-Chemical Machining Process ... *J. B. Riggs, R. H. Muller and C. W. Tobias.*
- LBL-8338: Cyclobutadiene Metal Complexes as Potential Intermediates in Alkyne Metathesis. Four-Ring Openings, Alkyne Rotations, and Reclosures in the Flash Vacuum Pyrolysis of Substituted η^4 -Cyclobutadiene- η^5 -Cyclopentadienyl Cobalt Complexes ... *J. R. Fritch and K. Peter C. Vollhardt.*
- LBL-8354: On the Location of Metastable Immiscibility in the SiO_2 - Al_2O_3 System ... *S. H. Risbud and J. A. Pask.*
- LBL-8456: Kinetics of Clustering Reactions ... *E. S. Pundarika and J. W. Morris, Jr.*
- LBL-8458: Thermal Expansion, Elasticity and Internal Friction of Polycrystalline PZT Ceramic ... *D. R. Biswas, S. Chandratreya and J. A. Pask.*
- LBL-8471: Reaction of a Metal Alkyl with Ethylene as a Model for Ziegler-Natta Polymerization. Evidence for the Olefin Insertion Mechanism ... *E. R. Evitt and R. G. Bergman.*
- LBL-8525: The Halo Effect in Jet Impingement Solid Particle Erosion Testing of Ductile Metals ... *L. Lapides and A. Levy.*
- LBL-8545: The Photodissociation of Formaldehyde: Potential Energy Surface Features ... *J. D. Goddard and H. F. Schaefer III.*
- LBL-8589: Collisions of Halogen (2p) and Rare Gas (1s) Atoms ... *C. H. Becker ... (Ph.D. thesis).*
- LBL-8637: Experimental and Computational Study of $\text{HF} + \text{Xe}$ Scattering ... *C. H. Becker, P. W. Tiedemann, J. J. Valentini, and Y. T. Lee, and R. B. Walker.*
- LBL-8649: Tunneling Corrections to Unimolecular Rate Constants with Application to Formaldehyde ... *W. H. Miller.*
- LBL-8660: Direct Observation of Voltage Barriers in ZnO Varistors ... *O. L. Krivanek, P. Williams, Yi-Ching Lin.*
- LBL-8677: Recent Progress in the Semiclassical Theory of Electronically Non-Adiabatic Collision Processes ... *W. H. Miller.*
- LBL-8691: A Unified Model for Diffractive and Inelastic Scattering of a Light Atom From a Solid Surface ... *J. E. Adams and W. H. Miller.*
- LBL-8716: Evidence for Alkylidene Intermediates in Fischer-Tropsch Synthesis Over Ru ... *J. G. Ekerdt and A. T. Bell.*
- LBL-8718: Electronic Structure in GaAs/Ge Through Angle-Resolved Photoemission ... *D. Denley, K. A. Mills, P. Perfetti and D. A. Shirley.*

LBL-8751: Multiphoton Dissociation of Polyatomic Molecules ...
P. A. Schulz, Aa. S. Sudbø, D. J. Krajnovich, H. S. Kwok, Y. R. Shen, and Y. T. Lee.

LBL-8754: Coal Liquefaction Alloy Test Program Annual Report FY 1978 ... A. Levy, W. Lochmann, and I. Cornet.

LBL-8765: Photoionization Study of Multiphoton Excited SF₆ in A Molecular Beam ... Aa. S. Sudbø, P. A. Schulz, D. J. Krajnovich, Y. T. Lee and Y. R. Shen.

LBL-8791: Interdiffusion in Ternary Co-Cr-Al Alloys ... G. W. Roper and D. P. Whittle.

LBL-8857: Thermal Degradation of a Black Chrome Solar Selective Absorber Coating ... C. M. Lampert.

LBL-8858: Proton Affinities of Hydrogen Halides Determined by the Molecular Beam - Photoionization Method ... P. W. Tiedemann, S. L. Anderson, S. T. Ceyer, T. Hirooka, C. Y. Ng, B. H. Mahan, and Y. T. Lee.

LBL-8861: Fluorescence Decay of the O_u⁺ and I_u States of Xe₂ ... G. Thornton, E. D. Poliakoŕŕ, E. Matthias, S. H. Southworth, R. A. Rosenberg, M. G. White, and D. A. Shirley.

CALENDAR

SURFACE SCIENCE AND CATALYSIS SEMINARS, 1:00 p.m., Bldg. 62, Rm. 203.

May 2: "TBA", Dr. Frennet, Stanford University.

May 9: "TBA", Prof. E. Muetterties, LBL

May 11: "Synthetic Fuels from Coal and Oil Shale---Matching Raw Material to Product," Dr. Henry Linden, Gas Research Inst.

May 16: "Heterogeneous Catalysis at Celanese," Dr. Leon B. Levy, Celanese Corp.

May 23: "Relationship Between the Surface Chemistry of Molybdena-Alumina Catalysts and Their Catalytic Function," Prof. W. Keith Hall, University of Wisconsin.

June 14: Gareth Thomas, Prof. of Metallurgy, UCB, will speak on "Electron Microscopy in Materials Science Today and Future Projects," LBL Colloquium, Bldg. 50 Auditorium, 4:00 PM.

Special thanks to LBL Librarian, Richard Robinson, for research assistance.