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Conference Reports

SIXTH INTERNATIONAL CONFERENCE ON HIGH TEMPERATURES—CHEMISTRY OF INORGANIC MATERIALS Gaithersburg, MD April 3–7, 1989

Report prepared by

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This conference was the sixth of a series, sponsored by the International Union of Pure and Applied Chemistry (IUPAC) Commission II.3 on High Temperature and Solid State Chemistry, and which is held about every 3 years.

The NIST meeting represented only the second occasion that this conference series had been held in the U.S.A. Attendance, exceeding 170, included participants from 19 countries, and 130 papers were presented.

1. About the Conference

The conference program emphasized the basic chemical science and measurement issues underlying the characterization, processing, and performance of materials at high temperatures. Each of the major classes of materials was considered, including high performance alloys, ceramics, composites, and specialized forms such as films, coatings, clusters, powders, slags, fluxes, etc. in addition, individual substances, namely the elements and their compounds, were discussed in detail. Seven plenary lectures and 68 invited talks were given as well as 61 poster presentations and computer-based demonstrations. Also, Prof. Leo Brewer, one of the foremost pioneers of the field, gave an overview of the conference proceedings together with his perspective on the "Role of Chemistry in High-Temperature Materials Science and Technology." During the conference sessions, many of the hot issues of the day were also discussed, including cold fusion, high-temperature superconductors, low pressure production of diamond films, etc.

Participation by the leading international researchers in the field was particularly strong in the materials-related areas of measurement techniques, thermochemistry and models, processing and synthesis, and performance under extreme environments. Of special interest were the topics on databases and phase equilibria models, processing—mainly from the vapor phase, and high power laser-materials interactions.

The conferees were welcomed by Dr. Lyle Schwartz, Director of the Institute for Materials Science and Engineering (IMSE) (now Materials Science and Engineering Laboratory), who also gave an overview of pertinent NIST and IMSE research activities. Prof. Jean Drowart of the Free University of Brussels, Belgium, addressed the meeting on behalf of IUPAC and gave a fascinating account of "7000 Years of High Temperature Materials Chemistry."

A few representative technical highlights from each of the main conference sessions are given in the following discussion.

2. Advances in Measurement Techniques

Three areas were given special emphasis. These were spectroscopic probes, diffractometry, and physicochemical methods. The types of spectroscopic probes discussed included Raman and related laser spectroscopic methods for *in situ* molecular-level or phase-specific monitoring of hot surfaces. Examples were considered in the areas of corrosion, oxide superconductor processing, and in Raman imaging of ceramic crack suppression due to phase transformation toughening (see fig. 1). An interesting novel application of *in situ* optical emission spectroscopic analysis of molten steel, using a laser-induced plasma-forming technique, was also discussed (see fig. 2). These effectively nonintrusive methods also have potential as process monitoring probes for intelligent processing in addition to their utility in experimental systems.

In the area of diffractometry, *in situ* analysis of material structures at high temperatures, using x-ray and neutron sources, was described. Atom probe chemical analysis on alloy surfaces using field-ion microscopy was also discussed.

Physicochemical techniques have traditionally been key to the characterization of materials at high temperatures and significant recent advances have occurred in this area. Methods have been developed which effectively eliminate containment problems. For instance, with liquid metals, transient microsecond time scale techniques have been applied to accurate measurements of melting points and heat capacities at very high temperatures. For steady state measurements, electromagnetic levitation may be used as, for instance, with emissivity and optical constant measurements. Another transient technique that was discussed by a number of researchers throughout the conference is the pulsed laser-heating approach to the production of vapor species for mass and optical spectroscopic characterization.

3. Thermochemistry and Models

This session was particularly well represented by the leaders in the field. Progress on development of thermodynamic databases was reviewed by researchers from the United States, U.S.S.R., Canada, France, Sweden and the United Kingdom. While the databases developed thus far are incomplete they are still sufficiently extensive to allow their use in thermochemical and phase equilibria models for many high-temperature alloy, ceramic, composite, slag, glass, and other systems. A key element in these models is the description of nonideal mixing, present in many practical systems. Among the various models considered, those accounting for ordering or formation of liquid associates appear particularly promising (see fig. 3). In one of the presentations, direct experimental (neutron diffraction) evidence was presented for ordering in liquid alloys (see fig. 4). Many papers were presented dealing with experimental determinations of thermochemical data and applications of the data to materials process development.

4. Processing and Synthesis

The chemical basis for high temperature processing and synthesis of materials is a rapidly growing area of research and representative work in the field was discussed. An area of significant promise for the design of new or improved materials is that of molecular/atomic clusters. These species, with properties intermediate between molecular and bulk material, are key reaction intermediates to most deposition and condensation processes. They also serve as model structures for surfaces owing to their intrinsic high ratio of surface to bulk atoms. Their unique reactivity as a function of cluster size was indicated by several speakers (see fig. 5).

The session on CVD and other vapor phase-based processes was particularly exciting. Thermochemical, kinetic, transport models, whereby the processing of films (diamond, semiconductor, ceramic, alloy, etc.) could be optimized, were described (see fig. 6).

5. Performance Under Extreme Environments

The important related areas of hot and high temperature corrosion were discussed for both alloy and ceramic materials. In particular, the key role of chemical reaction and solubility was demonstrated (see fig. 7).

Another area where materials are subject to extreme conditions is that of laser-materials interactions. There are many areas of science and technology that require an improved understanding of this interaction, including design of laser resistant materials, laser deposition of films, laser etching for electronic devices, laser stimulated chemical processing, laser welding, and laser heating for containerless studies of thermochemistry at ultra-high temperatures. This latter case has special significance to providing thermodynamic data for nuclear reactor excursions (see fig. 8) and for materials data for advanced aerospace applications.

6. Additional Information

A three volume proceedings (1350 pages) is being published by Humana Press, Clifton, NJ. Many of the conference presentations will appear in these volumes. Also included are a few articles, not presented at the conference, in order to provide a more complete coverage of certain topics. This will be the first generally available publication for this subject area and the proceedings should be of considerable interest to researchers, students, and others interested in the scientifically challenging, and technologically indispensable, interplay between materials and high temperatures.

The next meeting in the series is scheduled to be held in 1991 in Orleans, France and will be chaired by J. P. Coutures.

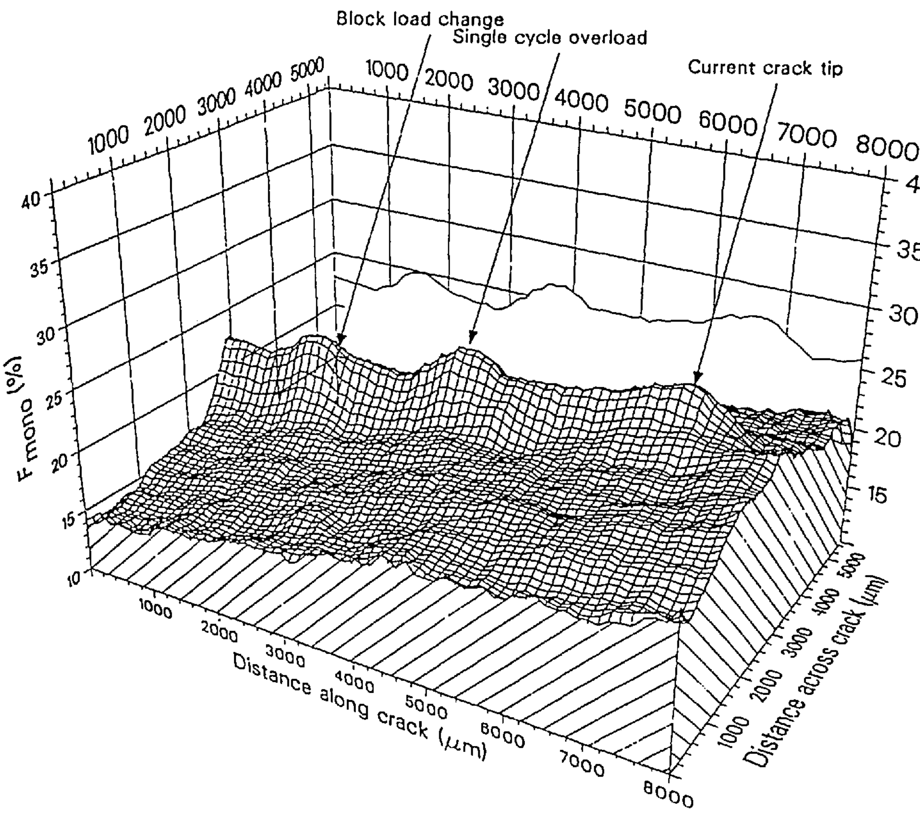

Figure 1. A map of the monoclinic phase fraction of a zirconia specimen subjected to an applied stress and crack growth. The stress history of the material is revealed in the extent and degree of transformation of the transformed zone. Large stresses induce a larger transformed zone around the crack tip that remains after the crack tip moves forward. (Taken from Rosenblatt et al., paper 4.)

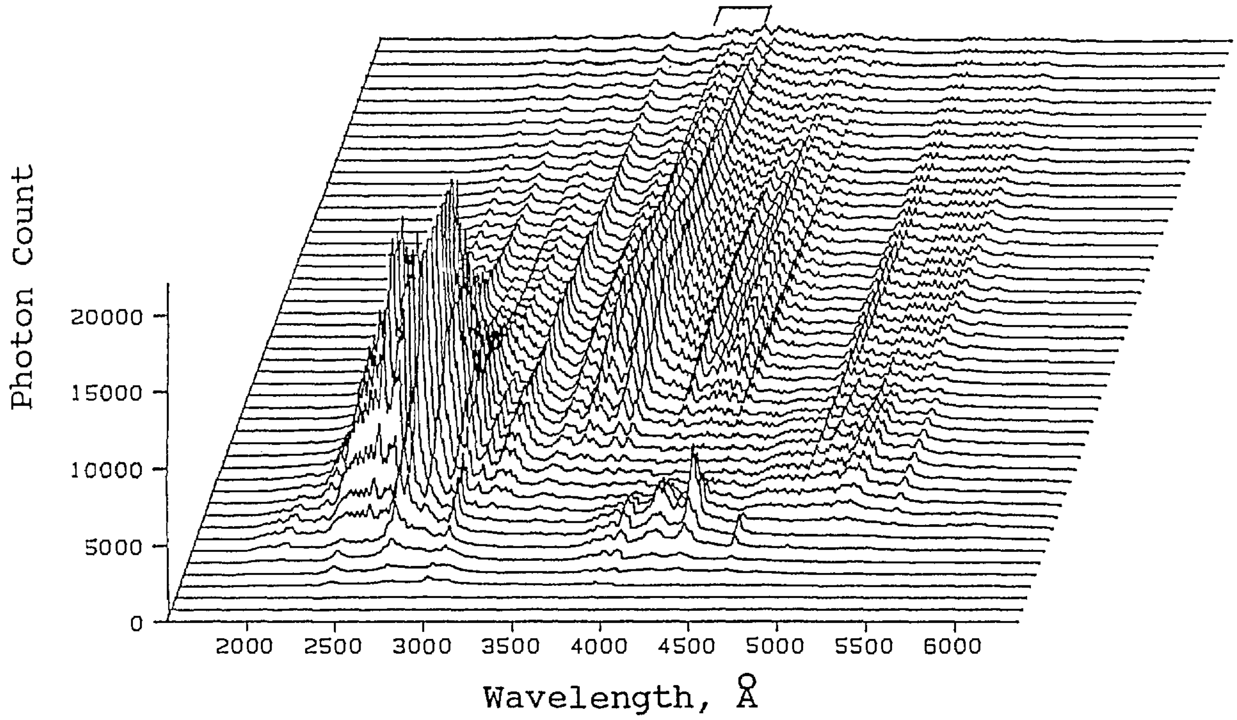

Figure 2. Time-resolved emission spectra from a laser produced plasma plume generated off a specialty steel alloy target. Each trace represents a 20 ns exposure spectrum covering the spectral range of 1850 to 6200 Å. Each successive trace is delayed by 20 ns and the 50 traces shown cover the first 1 μs of the plume. The laser energy is 3.38 J and the ambient gas is argon at 0.015 Torr at room temperature. (Taken from Kim, paper 5.)

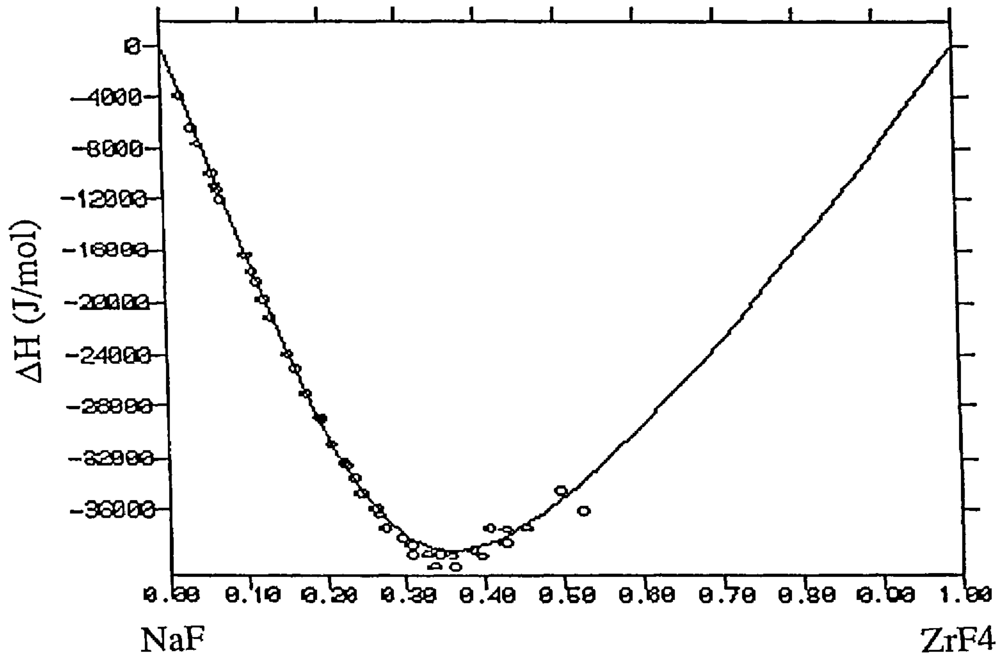

Figure 3. Enthalpy of mixing of the NaF-ZrF_4 system. Data points are experimental and line is calculated using an associated liquid model. (Taken from Gaune-Escard et al., paper 35.)

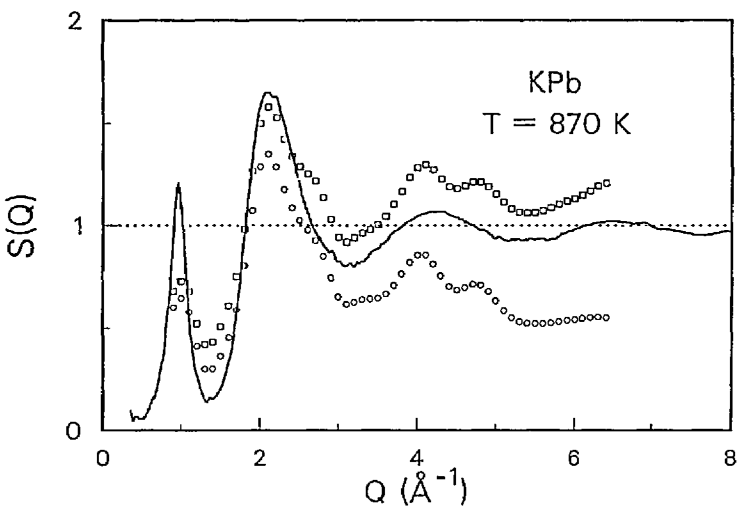

Figure 4. Structure factors, $S(Q)$, for liquid KPb. Solid line: $S(Q)$ from diffraction measurements on SEPD; Points $S_\Delta(Q)={}_{-\Delta}\int^{\Delta}S(Q,E)$ from inelastic scattering measurements on LRMECS: (□)Δ=40 meV, (o)Δ=5 meV. (Taken from Saboungi et al., paper 27.)

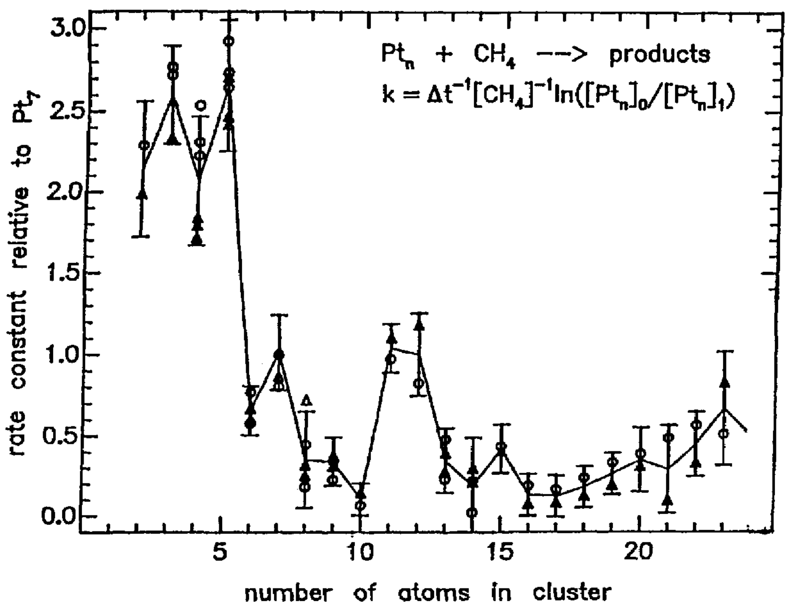

Figure 5. Reaction rate of Pt_x with CH_4, normalized to Pt_7. (Taken from Kaldor et al., paper 77.)

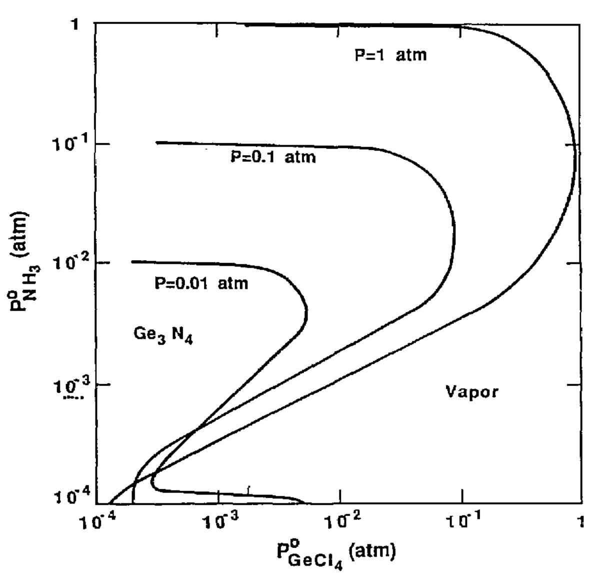

Figure 6. Phase fields for deposition of Ge_3N_4 as a function of deposition temperature and the feed ratio $P^0_{NH_3}/P^0_{GeCl_4}$ for the $GeCl_4$-NH_3-N_2 system. $P=1$ atm and $P^0_{GeCl_4}=10^{-2}$ atm. (Taken from Anderson et al., paper 105.)

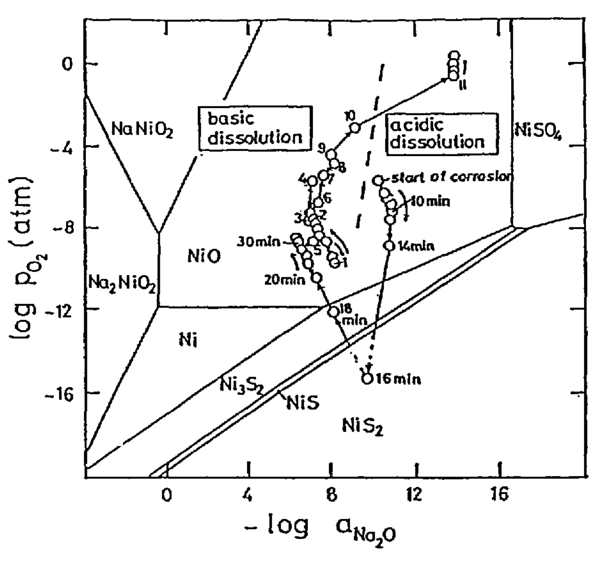

Figure 7. Trace of basicity and oxygen activity measured for preoxidized 99% Ni covered with a Na_2SO_4 film at 900 °C in 0.1% SO_2-O_2 gas atmosphere (preoxidized at 900 °C for 4 h in O_2). Numbers designate reaction time in hours except as indicated. Severe corrosion conditions. (Taken from Rapp, paper 115.)

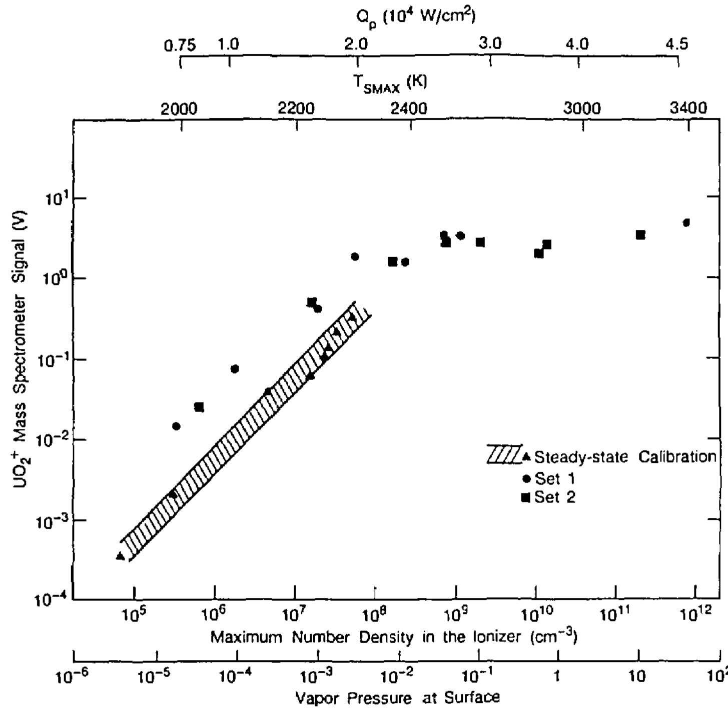

Figure 8. Maximum UO_2^+ signals from the mass spectrometer for laser pulses of varying strength. Q_p is the peak absorbed power density, and T_{smax} is the measured maximum surface temperature in the pulse. The scale designating the maximum number density in the ionizer of the mass spectrometer was calculated from measured ion intensities and the vapor pressure (Torr) is that of UO_2 at the peak surface temperature. The hatched area represents the range of results of the steady-state calibrations. (Taken from Olander, paper 123.)

7. List of Papers Presented at the Conference

ADVANCES IN MEASUREMENT TECHNIQUES

Spectroscopic Probes

1. *R. J. M. Anderson* and J. C. Hamilton—(Sandia National Lab., United States) **Nonlinear Optical Spectroscopy as a Probe of Properties and Processes at Surfaces and Interfaces**
2. *K. F. McCarty*, D. R. Boehme, D. S. Ginley, E. L. Venturini, and B. Morosin (Sandia National Labs., United States) **High-Temperature Processing of Oxide Superconductors: A Raman Scattering Study**
3. *M. D. Allendorf*—(Sandia National Labs., United States) **Temperature Measurements in Silica-Laden Flames by Spontaneous Raman Scattering**
4. *G. M. Rosenblatt* and D. K. Veirs —(Lawrence Berkeley Lab., United States) **Recent Developments using Imaging Detectors for Raman Characterization of High Temperature Materials**
5. *Y. W. Kim*—(Lehigh Univ., United States) **Laser Plasma Plume Analysis in High Temperature Condensed Phases**
6. *Y. Shiraishi* and K. Kusabiraki—(Tohoku Univ., Japan) **Infrared Spectrum of High Temperature Melts by Means of Emission Spectroscopy**
7. *I. R. Beattie*, N. Binsted, W. Levason, J. S. Ogden, M. D. Spicer, and N. A. Young—(Univ. Southhampton, United Kingdom) **EXAFS, Matrix Isolation and High Temperature Chemistry**

Diffractometry

8. *H. F. Franzen* and S.-J. Kim—(Iowa State Univ., United States) **High Temperature X-Ray Diffraction and Landau Theory Investigations of Thermal Symmetry-Breaking Transitions: The W Point of Fm3m and the Structure of NbN_{1-x}**
9. *R. D. Shull* and J. P. Cline—(NIST, United States) **High Temperature X-Ray Diffractometry of Ti-Al Alloy Phase Transitions**
10. *J. Faber, Jr.* and R. L. Hitterman—(Argonne National Lab., United States) **High Temperature insitu Neutron Diffraction Studies of the Defect Structure of Non-stoichiometric Oxides**
11. *P. P. Camus*—(NIST, United States) **Field-Ion Microscopy and Atom Probe Chemical Analysis**

Physico-Chemical Methods

12. *A. Cezairliyan*—(NIST, United States) **A Microsecond-Resolution Transient Technique for Thermophysical Measurements on Liquid Refractory Metals**
13. *R. H. Hauge*, S. Krishnan, G. P. Hansen, and J. L. Margrave—(Rice Univ., United States) **Emissivities and Optical Constants of Electromagnetically Levitated Liquid Metals as Functions of Temperature and Wavelength**
14. *M. Shamsuddin*[1]—(Banaras Hindu Univ., India) **Techniques for Measurement of Thermodynamic Properties of Chalcogenides**
15. *M. V. Korobov*[1], E. B. Rudnyi, O. M. Vovk, E. A. Kibicheva and L. N. Sidorov—(Moscow State Univ., U.S.S.R) **Ion Equilibria—A New Technique for Measurement of Low O_2 Partial Pressures**
16. *M. A. Frisch* and E. A. Giess —(IBM Yorktown Heights, United States) **Kinetics of Water Desorption from Glass Powders Studied by Knudsen Effusion Mass Spectrometry**
17. *K. A. Gingerich*, M. J. Stickney, and M. S. Chandrasekharaiah—(Texas A&M Univ., United States) **A Novel Vapor Source for the Thermodynamic Study of Alloys with a High Temperature Mass Spectrometer**
18. *D. Bostrom*, *B. Lindblom*, E. Rosen, and M. Sodelund—(Univ. Umea, Sweden) **The Zero Point Technique: An Improved Method to Determine Equilibrium Oxygen Partial Pressure of Slow Reacting Chemical Systems at High Temperatures**
19. *K. Zmbov*, J. W. Hastie, D. W. Bonnell, and D. L. Hildenbrand—(Boris Kidric Inst., Yugoslavia) **Mass Spectrometric Analysis of LiF and AgCl Vaporization and Temperature Dependent Electron Impact Fragmentation**

THERMOCHEMISTRY AND MODELS

Databases and Phase Equilibria Models

20. *L. V. Gurvich*—(Institute of High Temperature, U.S.S.R.) **Reference Books and Databanks on the Thermodynamic Properties of Inorganic Substances**
21. *M. W. Chase* and R. D. Levin—(NIST, United States) **Thermodynamic Properties of the Alkaline Earth Hydroxides: A JANAF Case History**
22. *I. Ansara*—(Domaine Univ., France) **Thermodynamic Modeling of Solution Phases and Phase Diagram Calculations**
23. *A. D. Pelton*, W. T. Thompson, and C. W. Bale—(Ecole Polytechnique, Canada) **Thermodynamic Databases for Multicomponent Solution-Modeling and Data Evaluations**
24. *M. H. Rand*, R. H. Davies, A. T. Dinsdale, T. G. Chart, and T. I. Berry—(Harwell Lab. Didcot, United Kingdom) **Application of MTDATA to the Modelling of Multicomponent Equilibria**
25. *B. Jonsson* and B. Sundman —(Royal Institute of Technology, Sweden) **Thermochemical Applications of THERMO-CALC**
26. *M. Seapan* and J. Y. Lo—(Oklahoma State Univ., United States) **A Simulation Model to Predict Slag Composition in a Coal Fired Boiler**
27. *M. L. Saboungi*, G. K. Johnson, and D. L. Price—(Argonne National Lab., United States) **Ordering in Some Liquid Alloys**
28. *M. Ramanathan*, S. Ness, and D. Kalmanovitch—(Univ. of North Dakota, United States) **New Techniques for Thermochemical Phase Equilibrium Predictions in Coal Ash Systems**
29. *R. G. Reddy* and H. Hu—(Univ. Nevada-Reno, United States) **Modeling of Viscosities of Alkali-, Alkaline-Earth Metal Oxide and Silicate Melts**
30. *M. W. Chase*, F. Glasser, and A. Bernstein—(NIST, United States) **PC Demonstration of Thermodynamic Databases**
31. *L. V. Gurvich*, V. S. Iorish and V. S. Youngman—(Institute of High Temperature, U.S.S.R.) **Extended and Updated Data Bank on Thermodynamic Properties of Inorganic Substances**
32. *D. W. Bonnell* and J. W. Hastie—(NIST, United States) **A Predictive Slag Phase Equilibria Model**
33. *H. M. Ondik*—(NIST, United States) **The NIST—ACerS Ceramic Phase Diagram Data Base**
34. *M. Gaune-Escard*, J. P. Bros, and G. Hatem—(Univ. de Provence, France) **Thermosalt, A Thermodynamic Data Bank for Molten Mixtures**
35. *M. Gaune-Escard* and G. Hatem—(Univ. de Provence, France) **Thermodynamic Modelling of High Temperature Melts and Phase Diagram Calculations**

Phase Equilibria Experimental and Applications

36. *P. W. Gilles* and G. F. Kessinger—(Univ. of Kansas, United States) **The High Temperature Vaporization and Thermodynamics of the Magneli Phases of the Titanium-Oxygen System**
37. *C. B. Alcock*—(Univ. Notre Dame, United States) **Strontium Oxide Activities in Oxide Ceramics**
38. *J.-C. Lin* and Y. A. Chang—(Univ. Wisconsin, United States) **Thermodynamics, Kinetics and Interface Morphology of Reactions Between Metals and III-V Compound Semiconductors**
39. *E. Kaldis*—(ETH-Zurich, Switzerland) **Thermodynamic Instabilities in High-Temperature Compounds With Intermediate Valence**
40. C. K. Mathews[1]—(Indira Gandhi Centre for Atomic Research, India) **Recent Studies on Thermochemistry and Phase Equilibria in Alkali Metal Systems**
41. *M. Iwase*, M. F. Jiang, and E. Ichise—(Kyoto Univ., Japan) **Thermochemistry of the System $MO+MX_2+Fe_xO$ (M=Ca, Sr, Ba, and X=F, Cl)**
42. A. I. Saitzev, N. V. Korolev, and B. M. Mogutnov[1]—(I. P. Bardin Research Institute, U.S.S.R.) **Thermodynamic Properties and Phase Equilibria at High Temperatures in CaO-CaF_2, Al_2O_3-CaO, and CaF_2-Al_2O_3-CaO Systems**
43. *H. Ipser*, R. Krachler, G. Hanninger, and K. L. Komarek—(Univ. of Vienna, Austria) **Thermodynamic Properties of NiAs-Type $Co_{1\pm x}Sb$ and $Ni_{1\pm x}Sb$**
44. A. I. Saitzev, M. A. Semchenko, and B. M. Mogutnov[1]—(I. P. Bardin Central Research Institute, U.S.S.R.) **Thermodynamic Properties and Phase Equilibria at High Temperatures in Fe-Cr and Fe-Mn Systems**
45. *M. Pelino*, A. Florindi, and M. Petroni—(Univ. dell'Aquila, Italy) **Study of the Decomposition Process of α-Goethite by Thermal Gravimetry "in Vacuo"**
46. *L. P. Cook*, E. R. Plante, D. W. Bonnell, and J. W. Hastie—(NIST, United States) **Reaction of Liquid Li, Al and Mg with Gaseous Cl_2, O_2 and F_2**
47. *R. H. Hauge*, M. Sampson, J. L. Margrave, J. Porter, and G. Reynolds—(Rice Univ., United States) **Mass Spectrometric Studies of the Vaporization Behavior of $SrZrO_3$, $SrHfO_3$, Yttria Stabilized Hafnia and $Ir_{0.4}Al_{0.6}$**
48. *K. Hilpert* and M. Miller - (Nuclear Research Center, Federal Republic of Germany) **Chemical Vapor Transport and Complexation in the NaI-ScI_3 System**
49. *K. Hilpert*, S. R. Dharwadkar, D. Kobertz, V. Venugopal, and H. Nickel—(Nuclear Research Center, Federal Republic of Germany) **Differential Thermal Analysis and Knudsen Effusion Mass Spectrometry in the Determination of Phase Equilibrium Diagrams in Nickel Based Superalloys**
50. *J. C. Liu*, M. P. Brady, and E. D. Verink, Jr.—(Univ. of Florida, United States) **Phase Stability and Kinetics Study in High Temperature Oxidation of Nb Ti-Al Alloys**
51. *D. Hoelzer* and F. Ebrahimi—(Univ. of Florida, United States) **Phase Stability in the Nb-Ti-Al Ternary System**
52. *E. M. Foltyn*—(Los Alamos National Lab., United States) **Allotropic Transitions in Neptunium Metal by Differential Thermal Analysis**
53. *B. M. Mogutnov*,[1] A. I. Saitzev, and N. V. Korolev—(I. P. Bardin Central Research Institute for Ferrous Metallurgy, U.S.S.R.) **The Vapor Pressures and the Heats of Sublimation of CaF_2 and SrF_2**
54. *B. M. Mogutov*[1] and A. I. Saitzev—(I. P. Bardin Central Research Institute for Ferrous Metallurgy, U.S.S.R.) **The Vapor Pressures and the Heats of Sublimation of Some Rare Earth Metals**
55. *J. M. Leitnaker*, R. W. Nichols, and B. S. Lankford—(Martin Marietta Energy Systems Oak Ridge, United States) **Reactions of Aluminum with Uranium Fluorides and Oxyfluorides**

Basic Data Determinations

56. *J. Drowart*, A. V. Gucht, S. Smoes—(Free Univ. Brussels, Belgium) **Mass Spectrometric Investigation of Systems Far From Thermodynamic Equilibrium Using the Knudsen Effusion Method**
57. *L. N. Gorokhov*, A. M. Emelyanov, and M. V. Milushin—(High Temp. Inst.,U.S.S.R.) **Knudsen Effusion Mass Spectrometry Determination of Metal Hydroxide Stabilities**
58. *V. L. Stolyarova*—(Silicate Inst. Academy of Sciences, U.S.S.R.) **Mass Spectrometric Study and Calculation of Thermodynamic Properties of Glass-Forming Oxide Systems**
59. *C. E. Myers*, G. A. Murray, R. J. Kematick, and M. A. Frisch—(State Univ. New York at Binghamton, United States) **Comparison of Knudsen Vaporization by Magnetic and Quadrupole Mass Spectrometric Techniques**
60. *J. G. Edwards* and J. K. R. Weber—(Univ. of Toledo, United States) **Vaporization Chemistry in the CaS-Ga_2S_3 System**
61. *G. Balducci*, G. De Maria, G. Gigli, and M. Guido—(Univ. di Roma 'La Sapienza', Italy) **Vaporization Behavior of Molten Alkali Metal Metavanadates**
62. *J. K. Gibson* and R. G. Haire—(Oak Ridge National Lab., United States) **Knudsen Effusion Investigation of the Thermal Decomposition of Transplutonium Hydrides**
63. *P. W. Gilles* and M. A. Williamson—(Univ. of Kansas, United States) **Vaporization Chemistry of the Vanadium Selenides**
64. *R. G. Haire* and J. K. Gibson—(Oak Ridge National Lab., United States) **On the Enthalpies of Sublimation of Einsteinium and Fermium**
65. *D. L. Hildenbrand*, K. H. Lau, and R. D. Brittain—(SRI International, United States) **Mechanistic Aspects of Metal Sulfate Decomposition Processes**
66. *K. Hilpert* and K. Ruthardt—(Nuclear Research Centre, Federal Republic of Germany) **Determination of the Enthalpy of Dissociation of the Molecule CrPb by High Sensitivity Knudsen Effusion Mass Spectrometry**

67. *P. D. Kleinschmidt* and K. Axler—(Los Alamos National Lab., United States) **Activity and Free Energy of Formation of the Compound $CaCsCl_3$**
68. *P. C. Nordine*, R. A. Schiffman, and J. K. R. Weber—(Intersonics, Inc., United States) **Vapor Pressure of Boron**
69. *G. N. Papatheodorou* and L. Nalbandian—(Institute of Chemical Engineering and High Temperature Chemical Processes, Greece) **Raman Spectra and Vibrational Analysis of the Fe_2Cl_6, $FeAlCl_6$, Au_2Cl_6 and $AuAlCl_6$ Vapor Molecules**
70. M. Shamsuddin and A. Nasar[1]—(Banaras Hindu Univ., India) **Thermodynamic Properties of Cadmium Telluride**
71. *V. L. Stolyarova*, I. Y. Archakov, and M. M.Shultz—(Institute of Silicate Chemistry of the Academy of Sciences, U.S.S.R.) **High Temperature Mass Spectrometric Study of the Thermodynamic Properties of Borosilicate Systems**
72. *M. E. Jacox* and W. E. Thompson—(NIST, United States) **The Production and Spectroscopy of Small Polyatomic Molecular Ions Isolated in Solid Neon**
73. M. Shamsuddin,[1] A. Nasar, and V. B. Tare—(Banaras Hindu Univ., India) **Electrical Conductivity and Defect Structure of Cadmium Telluride**
74. *M. Gaune-Escard* and A. Bogacz—(Univ. de Provence, France) **Calorimetric Investigation of $NdCl_3$ and of $NdCl_3$-MCl Mixtures**
75. *J. P. Bros*, D. El Allam, M. Gaune-Escard, and E. Hayer—(Univ. de Provence, France) **Enthalpies of Formations of Ni- and Pd-Based Ternary Alloys**
76. *C. B. Coughanowr*, T. J. Anderson, and J. J. Egan—(Univ. of Florida, United States) **Thermodynamic Investigation of the Al-Sb and Al-In Systems by Solid State Electrochemistry**

PROCESSING AND SYNTHESIS

Clusters as Reaction Intermediates and Model Structures

77. *A. Kaldor*—(Exxon Research and Engineering, United States) **Clusters as Intermediates for New Materials**
78. *F. W. Froben*, T. M. Chandrasekhar and J. Kolenda—(Freie Univ. Berlin, Federal Republic of Germany) **Cluster Production by Laser Material Interaction With Optical Spectroscopic Characterization**
79. *M. Vala*, T. M. Chandrasekhar, and J. Szczepanski—(Univ. of Florida, United States) **Spectroscopy and Structure of Small Carbon Clusters**
80. *K. G. Weil* and A. Hartman—(Technische Hochschule Darmstadt, Federal Republic of Germany) **Mechanism of Cluster Formation during Evaporation of Alloys**
81. *K. Hilpert* and D. Kath—(Nuclear Research Centre, Federal Republic of Germany) **Investigation of Small Alkali Metal Clusters by Knudsen Effusion Mass Spectrometry using Broad Band Photoionization**
82. *T. C. DeVore* and J. L. Gole—(James Madison Univ., United States) **Oxidation of Small Metal Clusters**
83. *R. S. Berry*, H.-P. Cheng, and J. Rose—(Univ. of Chicago, United States) **Freezing and Melting of Metallic and Salt-Like Clusters**
84. *E. Blaisten-Barojas* and M. Nyden—(NIST, United States) **Thermal Fragmentation of Long Carbon Chains**
85. *K. A. Gingerich*, J. E. Kingcade, Jr., and I. Shim—(Texas A&M Univ., United States) **Bond Energies and Nature of Bonding in Small Transition Metal Semiconductor Clusters**
86. *P. J. Ficalora* and J. H. Hawley—(Rensselaer Polytechnic Institute, United States) **Heterogeneous Formation of Aluminum Vapor Clusters**

Nucleation and Growth of Small Particles

87. *J. Schoonman*, R. A. Bauer, and J. G. M. Becht—(Delft Univ. Technology, The Netherlands) **Laser-Chemical Vapor Precipitation of Ultrafine Ceramic Powders: Si and Si_3N_4**
88. *N. Shima* and K. Yoshihara—(Idemitsu Kosan Central Research Labs., Japan) **Laser Production of Metallic Fine Particles from Organometallic Compounds**
89. *J. L. Katz* and M. D. Donohue—(Johns Hopkins Univ., United States) **Nucleation with Simultaneous Chemical Reaction**
90. *P. R. Buerki*, T. Troxler, and S. Leutwyler—(Univ. Bern, Federal Republic of Germany) **Synthesis of Ultrafine Si_3N_4 Particles by CO_2-Laser Induced Gas Phase Reactions**
91. *M. R. Zachariah* and H. G. Semerjian—(NIST, United States) **Experimental and Numerical Studies of Refractory Particle Formation in Flames: Application to Silica Growth**

Processing, Mainly from the Vapor Phase

92. *K. E. Spear*—(Pennsylvania State Univ., United States) **The Role of High Temperature Chemistry in CVD Processing**
93. *C. Bernard*—(ENSEEG Domaine Univ., France) **Thermochemical Modeling of Vapor Deposition**
94. *Y. K. Rao* and Y. Do—(Univ. of Washington, United States) **Modeling of Chemical Vapor Deposition (or Etching) in Closed Systems**
95. *F. W. Smith*, M. Sommer, and K. Mui—(City College of the City Univ. of New York, United States) **Thermodynamic Analysis of the Chemical Vapor Deposition of Diamond Films**
96. *J. E. Butler*—(Naval Research Lab., United States) **The Chemical Vapor Deposition of Synthetic Diamond**
97. *E. Schnedler* and H. Greiner—(Phillips GmbH Forschungslaboratorium Aachen, Federal Republic of Germany) **Modelling of High Temperature Transport Reactions**
98. *J.-O. Carlssan*—(Uppsala Univ., Sweden) **Area Selective and Phase-Selective CVD on Patterned Substrates**
99. *R. Naslain* and F. Langlais—(Lab. des Composites Thermostructuraux, France) **Fundamental and Practical Aspects of the Chemical Vapor Infiltration of Porous Substrates**
100. *T. H. Baum* and C. E. Larson—(IBM Almaden Research Center, United States) **Laser Chemical Vapor Deposition of High Purity Metals**
101. *U. B. Pal* and S. C. Singhal—(Westinghouse R&D Center, United States) **Growth of Perovskite Films by Electrochemical Vapor Deposition**
102. *J. S. Horwitz* and M. C. Lin—(U.S. Naval Research Lab., United States) **Laser and Mass Spectrometric Studies of the Mechanism of Silicon Single Crystal Etching Reactions**
103. *Z. A. Munir*—(Univ. of California Davis, United States) **The Utilization of Combustion Processes for the Synthesis of High Temperature Materials**
104. *K. L. Komarek* and H. Blaha—(Institute of Inorganic Chemistry, Austria) **The Reduction of Silica With Graphite**
105. *T. J. Anderson*, J. L. Ponthenier, and F. Defoort—(Univ. of Florida, United States) **Thermodynamic Analysis of Ge_3N_4 Chemical Vapor Deposition**
106. *Z. H. Kafafi* and R. S. Pong—(Naval Research Lab., United States) **The Activation of the C-H Bond of Allene by Ground State Atomic Iron**
107. *T. C. DeVore*, M. L. Smith, and J. C. Fagerli—(James Madison Univ., United States) **Chemical Vapor Transported Species Resulting from the Oxidation of Hot W, Mo Filaments by N_2O, O_2, $POCl_3$, and K_2ClO_4**

Process Models and Materials by Design

108. *P. J. Spencer* and H. Holleck—(Lehrstuhl fur Theoretische Huttenkunde, Federal Republic of Germany) **Application of a Thermochemical Data Bank System to the Calculation of Metastable Phase Formation During PVD of Carbide, Nitride and Boride Coatings**
109. *P. R. Strutt* and G.-M. Chow—(Univ. of Connecticut, United States) **Ultrafine Composite Synthesis by Laser-Induced Reactive Evaporation and Rapid Condensation**
110. *J. W. Mitchell* and G. Cadet—(AT&T Bell Labs., United States) **Microwave Discharge Synthesis and Characterization of Materials**
111. *J. D. Corbett*, E. Garcia, Y.-U. Kwon, and A. Guloy—(Iowa State Univ., United States) **Chemical Clusters from Solid State Systems at High-Temperatures—Interstitials as a Means to Stability and Versatility**
112. *P. K. Khowash* and D. E. Ellis—(Northwestern Univ., United States) **Impurity Defect Structure in Alpha-Alumina**
113. *N. Zacchetti*, G. Fierro, G. M. Ingo, A. Mazzarano, S. Sturlese—(Centro Sviluppo Materiali SpA, Italy) **High Temperature Stability of CeO_2-Y_2O_3 Stabilized Zirconia Plasma Spray Powders: XPS and DTA Investigations**
114. *N. Zacchetti* and G. M. Ingo—(Centro Sviluppo Materiali SpA, Italy) **XPS Investigation on the Chemical Structure and Growth Model of Amorphous Silicon Nitride (a-SiNx)**

PERFORMANCE UNDER EXTREME ENVIRONMENTS

Hot Corrosion

115. *R. A. Rapp*—(Ohio State Univ., United States) **Hot Corrosion of Materials**
116. *R. L. Jones*—(Naval Research Lab., United States) **Oxide Acid-Base Reactions in Ceramic Corrosion**
117. *N. S. Jacobson*, J. E. Marra, E. R. Kreidler, and M. J. McNallan,—(NASA Lewis Research Center, United States), **High Temperature Reactions of Ceramics and Metals with Chlorine and Oxygen**
118. *N. Birks*, D. L. Rishel, and F. S. Pettit—(Univ. of Pittsburg, United States) **Erosion and Corrosion of Metals in Sulfurous Atmospheres**
119. *I. Tomizuka*, H. Numata, H. Harada, Y. Koizumi, and M. Yamazaki— (National Research Institute for Metals, Japan) **Effects in Processing History and Minor Element Contents on Hot-Corrosion Behavior of a Power-Metallurgically Prepared Nickel-Base Superalloy**
120. *W. Boersma-Klein* and J. Kistemaker—(FOM-Institute for Atomic and Molecular Physics, The Netherlands) **Material Transport at the Interface of a Graphite Wall and a U-C-F Gas/Liquid Mixture**
121. *E. Franconi*, M. Rubel, and B. Emmoth—(Associazione EURATOM-ENEA sulla Fusione Centro Ricerche Energia Frascati, Italy) **Deuterium Implanted in C+SiC and CL5890PT Materials**
122. *V. U. Kodash*, P. S. Kisley, and V. J. Shemet—(Institute of Superhard Materials, Academy of Sciences, U.S.S.R.) **High Temperature Oxidation of Molybdenum Aluminosilicides**

High Power Laser-Materials Interactions

123. *D. R. Olander*, S. K. Yagnik, and C. H. Tsai—(Univ. of California, United States) **Laser-Pulse-Vaporization of Uranium Dioxide and Other Refractory Materials**
124. *J. L. Lyman*, D. A Cremers, R. D. Dixon, R. C. Estler, G. K. Lewis, R. E. Muenchausen, N. S. Nogar, M. Piltch—(Los Alamos National Lab., United States) **Direct Laser/Materials Interaction: Laser Ablation of Superconductor Materials and Laser Welding**
125. *M. J. Berry*, T. D. Kunz, R. F. Menefee, and L. G. Fredin—(Rice Univ., United States) **Laser Probe Absorption Spectroscopy Measurements on Laser Induced Plumes**
126. *Y. Nishina* and A. Kasuya—(Materials Research Institute, Japan) **Space/Time Resolved Spectroscopic Analysis on High Power Laser-Materials Interaction**
127. *R. W. Dreyfus*—(IBM, Yorktown Heights, United States) **Interactive Effects in Excimer Laser Photoablation**
128. *K.-S. Lyu*, J. Kralik, and Y. W. Kim—(Lehigh Univ., United States) **Laser Produced High Temperature States for Iron**
129. *P. K. Schenck*, D. W. Bonnell, and J. W. Hastie—(NIST, United States) **Insitu Analysis of Laser-Induced Vapor Plumes**

CONFERENCE WRAP-UP

130. *L. Brewer*—(Univ. of California Berkeley, United States) **A Conference Overview with a Personal Perspective on the Role of Chemistry in High Temperature Materials Science and Technology**

[1] Paper presented in absentia.