

Soviet Aerospace Literature

This month: *Refractory Materials*

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A88-12197 Effect of the environment on the fracture of structural ceramics (Review) (Vlianie sredy na razrushenie konstruktivnoi keramiki /Obzor/) I. U. G. GOGOTSI, *Fiziko-Khimicheskaia Mekhanika Materialov* (ISSN 0430-6252), Vol. 23, July-Aug. 1987, pp. 73-82. 52 Refs.

The effect of chemically active working media, such as water, acid and alkali solutions, and high-temperature air, on the mechanical properties and corrosion behavior of structural ceramics based on Al_2O_3 , Si_3N_4 , and SiC is examined with reference to recent experimental and theoretical research in this field. In particular, attention is given to the mechanisms of stress corrosion cracking, test methods, and stress corrosion cracking characteristics of the classes of ceramic materials investigated. It is shown that the effect of the environment is significant in the case of both oxide and oxygen-free ceramics.

A87-53440 Evaluation of the tension diagrams of high-temperature metal materials (K otsenke diagramm rastiazheniia zharoprochnykh metallicheskiikh materialov) V. P. GOLUB, A. S. OLEINIK, and V. N. PAVLOV, *Problemy Prochnosti* (ISSN 0556-171X), July 1987, pp. 31-35. 7 Refs.

The effect of temperature and cyclic loading on the tension diagrams of high-temperature nickel alloys is investigated experimentally using specimens of commercial nickel alloys EI437B, EI867, EI827, and EI698VD. It is shown, in particular, that the presence of a high-frequency (greater than 10 Hz) component in the load generally lowers the short-term strength characteristics of the alloys. In the high-temperature region, small cyclic loads may lead to the hardening of the alloys without any decrease in their ductile characteristics.

A88-11406 Laser modification of thermally sprayed coatings (Modifikatsiia gazotermicheskikh pokrytii izlucheniem lazera) A. A. UGLOV, A. D. FOMIN, A. O. NAUMKIN, P. I. PEKSHV, I. I. SMUROV, et al. *Fizika i Khimiia Obrabotki Materialov* (ISSN 0015-3214), July-Aug. 1987, pp. 78-82.

Experimental results are reported on the modification of thermally sprayed coatings on steels and aluminum alloys using pulsed YAG and CW CO₂ lasers. In particular, results obtained for self-fluxing Ni9CrBSi powders, ZrO₂ ceramic, and titanium are examined. It is shown that the laser treatment of thermally sprayed coatings significantly improves their physicochemical properties; it also makes it possible to obtain refractory coatings on low-melting substrates with good coating-substrate adhesion.

A88-11230 Effect of heat treatment on the mechanical properties and fracture characteristics of sheet molybdenum alloys (Vlianie termicheskoi obrabotki na mekhanicheskie svoistva i kharakter razrusheniia listovykh molibdenovykh splavov) V. V. BUKHANOVSKII, N. G. KARTYSHOV, E. P. POLISHCHUK, V. K. KHARCHENKO, and M. I. CHIKUNOV, *Problemy Prochnosti* (ISSN 0556-171X), Aug. 1987, pp. 53-57. 11 Refs.

Experimental data are presented on the effect of the temperature of annealing (1223-2273 K) on the grain size, mechanical properties, and cold brittleness threshold of rolled sheets of Tsm-6 and Tsm-10 molybdenum alloys. It is found that an increase in annealing temperature is accompanied by a monotonic decrease in yield strength, this effect being particularly pronounced at the annealing temperature corresponding to the temperature region of primary recrystallization. It is also found that the ductility of molybdenum alloys is strongly affected by oxygen and carbon redistribution between the bulk of the grain and grain boundaries.

A87-43641 Strength and fracture toughness of ceramics. III - A silicon carbide ceramic (Prochnost' i treshchinostoikost' keramiki. III - Karbidremnievaia keramika) G. A. GOGOTSI, G. G. GNESIN, I. A. L. GRUSHEVSKII, and V. P. ZAVADA, *Problemy Prochnosti* (ISSN 0556-171X), no. 5, May 1987, pp. 77-80. 9 Refs.

The mechanical characteristics of a silicon carbide ceramic are investigated experimentally in the temperature range 20-1400 C. It is found that the ultimate tensile strength of the ceramic (170 MPa) is maintained in the temperature range 20-1200 C but decreases at higher temperatures. At 1400 C, the strength of the ceramic is only 43 MPa. It is also found that the critical stress intensity factor increases with temperature, which is explained by the softening of the silicon phase in the material.

A87-43640 A study of the thermal-stress state of gas turbine engine blades with protective coatings (Issledovanie termonapriazhennogo sostoiianiia modelei lopatok GTD s zashchitnymi pokrytiami) G. N. TERT'ACHENKO, K. P. BUISIKH, L. V. KRAVCHUK, and G. R. SEMENOV, *Problemy Prochnosti* (ISSN 0556-171X), no. 5, May 1987, pp. 67-70. 9 Refs.

Thermal stress analysis is carried out for wedge-shaped blade models of ZhS6U nickel alloy of three different sizes with heat-resistant electron-beam coatings of three different compositions (Ni-Co-Cr-Al-Y, Co-Cr-Al-Y, and Ni-Cr-Al-Y). It is shown that, in addition to protecting the blade surface against corrosion and erosion, the protective coatings are also capable of reducing thermal stresses in the surface layers of a structural element.

A87-43637 Creep effects under cyclic loading (O nekotorykh effekтах polzuchesti pri tsiklicheskiikh nagruzheniakh) V. P. GOLUB, *Problemy Prochnosti* (ISSN 0556-171X), no. 5, May 1987, pp. 20-24. 7 Refs.

Some newly discovered and known mechanical effects associated with the creep of heat-resistant metal materials under combined static and high-frequency cyclic loading are examined with reference to experimental results for high-temperature nickel-based alloys EI698VD, EI437B, EI867, EP109, and VZhL12U. The discussion covers the effect of the critical stress amplitude factor, the effect of creep intensification with respect to the mean stress, creep intensification with respect to the maximum stress, and the effect of reduced plasticity.

A87-42166 A study of the thermophysical properties of niobium in the high-temperature region (Issledovanie kompleksa teplofizicheskikh svoistv niobiia v oblasti vysokikh temperatur) V. E. PELETSKII, A. P. GRISHCHUK, E. B. ZARETSKII, and A. A. ZOLOTUKHIN, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 25, Mar.-Apr. 1987, pp. 285-291. 18 Refs.

Experimental data are presented on the temperature dependence of the heat conductivity of niobium in the range 400-2360 K, its thermal diffusivity (300-2370 K), and electrical resistivity (77-2670 K). Determinations are also made of the specific heat content and the Lorentz function. Some anomalies in the thermal diffusivity and conductivity polytherms of niobium are examined.

A87-42046 Strength of sintered heterophase TiN-Cr materials at room and high temperatures (Prochnost' spechennykh geterofaznykh materialov TiN-Cr pri komnatnoi i vysokikh temperaturakh) F. F. EGOROV, E. N. IVANOV, O. V. BAKUN, V. P. SMIRNOV, and V. V. ZAMETAILO, *Poroshkovaia Metallurgii* (ISSN 0032-4795), April 1987, pp. 96-100. 7 Refs.

The strength and fracture behavior of sintered TiN-Cr materials at room and high temperatures is investigated as a function of the contents of the principal components, phase composition, and porosity. It is shown that the temperature dependence of the strength characteristics of the material is nonmonotonic, with a maximum depending on the amount of the binder (high-alloy chromium). The yield strength of the material is largely determined by the binder content, its distribution, and porosity.

A87-42047 Structural transformations in heat-resistant protective coatings on nickel alloys (Strukturnye prevrashcheniia v zharostoikiikh zashchitnykh pokrytiakh na nikelovykh splavakh) I. G. VEKSLER, V. P. LESNIKOV, S. IA. PALEEVA, E. G. LESNIKOVA, and G. F. MIAL'NITSIA, *Metallovedenie i Termicheskaiia Obrabotka Metallov* (ISSN 0026-0819), no. 4, 1987, pp. 45-50. 9 Refs.

A study is made of the structural and phase transformations occurring in fused slurry aluminosilicide coatings (Al-Si and Al-Nb-Si) and in an electron-beam-deposited Co-Cr-Al-Y coating on EP-539 alloy during high-temperature and corrosion testing and during service. A model is developed which describes the disintegration of these coatings resulting from structural changes due to high-temperature gas corrosion. The role of the martensitic transformation of the beta phase (NiAl) in the deterioration of aluminosilicide coatings is examined.

A87-51015 Thermal conductivity of two-layer metallic systems at high temperatures - Titanium-molybdenum system (Temperaturoprovodnost' dvukhsloinykh metallicheskiikh sistem pri vysokikh temperaturakh - Sistema titan-molibden) I. G. KORSHUNOV, V. I. CHER-ANEV, V. E. ZINOV'EV, V. E. KOZHEVNIKOV, and A. A. KURICHENKO, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 25, May-June 1987, pp. 612-614. 5 Refs.

The high-temperature thermal conductivity of an explosion-welded bimetal plate consisting of VT-1-0 titanium and molybdenum containing less than 0.1 percent of impurities (by mass) is investigated experimentally in the temperature range 800-1800 K. The thermal conductivity of the bimetal specimens exhibits an anomalous behavior in the temperature range 1150-1180 K, which is attributed to the alpha-beta phase transformation occurring in titanium at about 1155 K. For the relative layer thickness investigated (Ti, 0.55; Mo, 0.45), the thermal conductivity of the Ti-Mo system is largely determined by the thermal conductivity of titanium.

A87-51005 Irreversible changes of the density of Al-Si melts at high temperatures (Neobratimye izmeneniia plotnosti rasplavov Al-Si pri vysokikh temperaturakh) P. S. POPEL', E. L. DEMINA, E. L. ARKHANGEL'SKII, and B. A. BAUM, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 25, May-June 1987, pp. 487-491. 22 Refs.

The temperature dependence of the density of hypoeutectic and eutectic Al-Si alloys are investigated experimentally in the temperature range 350-1450 C. An anomalous reduction in the thermal expansion coefficient is observed during the heating of the melt following the melting of an ingot; a further increase in temperature and subsequent cooling do not produce singularities on the polythermal density curves. The results are interpreted as evidence for the irreversible breakdown, during melt heating, of the metastable colloidal state formed during the melting of a dual-phase eutectic specimen or during component mixing under conditions of slight superheating above the liquidus line.

A87-49683 Effect of oils and structural materials on the formation of high-temperature deposits (Vliianie masel i konstruktsionnykh materialov na obrazovanie vysokotemperaturnykh otlozhenii) B. S. GUTENEV, N. P. POROIKOV, and V. N. BAKUNIN, *Khimiia i Tekhnologiiia Topliv i Masel* (ISSN 0023-1169), no. 6, 1987, pp. 22, 23. 7 Refs.

The objective of the study was to establish a relationship between the amount of deposits formed on the hot surfaces of gas turbine engine components, oil composition, and the nature of the structural materials in contact with the oil. A method and a test apparatus are described which make it possible to evaluate the effect of various structural materials on the formation of deposits. It is shown that copper, lead, and brass have a particularly strong catalytic effect on the formation of high-temperature deposits in the presence of oils. Various synthetic oils are evaluated with respect to their tendency to form deposits, and the mechanisms responsible for the formation of high-temperature deposits are briefly examined.

A87-46106 Analysis of mathematical models used in the thermal evaluation of the quality of composite materials (Analiz matematicheskikh modelei, ispol'zuemykh pri teplovom kontrole kachestva kompozitsionnykh materialov) G. G. TIVANOV, *Defektoskopiia* (ISSN 0130-3082), no. 5, 1987, pp. 53-55. 5 Refs.

An analysis is made of the temperature contrasts obtained during the thermal nondestructive evaluation of composite materials on the basis of isotropic and anisotropic models, and the applicability of parabolic heat conduction equations in thermal testing is examined. It is shown that the use of isotropic models during the thermal evaluation of composites not only makes it impossible to correctly identify defects but also, in certain cases, increases the probability of missing a defect. It is also emphasized that, in the case of plates and films, the minimum thickness for which the parabolic equation of heat conduction is still valid must be considered.

A87-46064 Effect of laser diffusion heat treatments on the structure and properties of titanium and its alloys (Vliianie lazernoi khimiko-termicheskoi obrabotki na stroenie i svoistva titana i ego splavov) I. U. M. LAKHTIN, I. A. D. KOGAN, D. P. SHASHKOV, L. A. TEPLOVA, and N. S. IUDINA, *Akademiia Nauk SSSR, Izvestiia, Metally* (ISSN 0568-5303), May-June 1987, pp. 161-166. 8 Refs.

The characteristics of the formation of a hardened layer on titanium alloys during laser diffusion heat treatments are investigated experimentally using samples of commercial titanium VT1-0, pseudo-alpha alloys AT-3 and AT-6, and an alpha-beta alloy, VT-22. It is shown that a maximum increase in the hardness of alpha and alpha-beta titanium alloys, without a substantial loss of ductility, is produced by laser carbosilicizing and carboboriding. These treatments also increase the high-temperature (500 C) strength of titanium and its alloys, which is explained by the formation of a complexly alloyed alpha-prime solid solution strengthened by borides or silicides.

A87-46063 Band energy and L1(0)-B2 phase transition in an NiMn alloy (Zonnaia energii i fazovoe prevrashchenie L1(0)-B2 v splave NiMn) V. S. DEMIDENKO, A. V. KOLUBAEV, and S. N. KUL'KOV, *Akademiia Nauk SSSR, Izvestiia, Metally* (ISSN 0568-5303), May-June 1987, pp. 128-132. 16 Refs.

The mechanism of the L1(0)-B2 phase transition is examined with reference to experimental data on the temperature dependence of the degree of atomic ordering in an NiMn alloy and the magnetic moment of Mn in the alloy. A model is proposed whereby this phase transition is defined as a structural transition initiated by atomic disordering. It is noted that atomic redistribution may be an important factor in high-temperature structural transformations observed in other systems, such as the formation of close-packed ordered sigma phases from a bcc solid solution.

A87-24399 Multilayer metal-oxide composites based on cast plasticized films with powder fillers (Mnogosloinnye metallo-oksidnye kompozity na osnove litnykh plastifitsirovannykh plenok s poroshkovymi napolniteliami) S. M. KATS, V. N. BOGIN, S. S. ORDANIAN, T. S. BASALAEVA, and N. G. CHUBENKO, *Poroshkovaia Metallurgii* (ISSN 0032-4795), Oct. 1986, pp. 71-78. 9 Refs.

Same aspects of the production of multilayer composites by the film casting technique are examined, as are possible applications of such materials. A study is then made of the physicomechanical properties (e.g., flexural strength, elastic modulus, brittleness, and heat conductivity) of some multilayer metal oxide composites, including Al₂O₃-Mo, ZrO₂-W, ZrO₂-Mo, and Y₂O₃-W. The stability of metal-oxide composites against oxidation is discussed.

A87-24400 Structural transformations in thermally sprayed coatings of Ni60Nb40 alloy during vacuum anneals (Strukturnye prevrashcheniia v gazotermicheskikh pokrytiakh iz splava Ni60Nb40 pri vakuumnykh otzhigakh) I. U. S. BORISOV, V. N. KORZHIK, I. U. A. KUNITSKII, S. L. REVO, and I. A. P. GRITSKIV, *Poroshkovaia Metallurgii* (ISSN 0032-4795), Oct. 1986, pp. 39-45. 11 Refs.

The structural transformations occurring in thermally sprayed coatings of Ni60Nb40 alloy during vacuum anneals at 300-1360 K are investigated experimentally using electron microscopy and X-ray diffraction and differential thermal analyses. It is found that, initially, the coatings generally have an amorphous structure. The amorphous matrix starts to decompose at 800 K with the precipitation of Ni₃Nb, which is accompanied by a loss of elasticity and ductility and changes in surface fracture morphology. It is also shown that the sequence of stable phase precipitation is reverse in comparison with that observed during the crystallization of amorphous ribbon alloys of similar composition.

A87-21656 High-temperature creep of powder-metallurgy nickel aluminide (Vysokotemperaturnaia polzuchest' poroshkovogo aluminida nikelia) S. M. BARINOV, P. V. ZUBAREV, V. S. IVANOV, and I. U. L. KRASULIN, *Akademiia Nauk SSSR, Izvestiia, Metally* (ISSN 0568-5303), Sept.-Oct. 1986, pp. 171-174. 11 Refs.

It is shown experimentally that the steady-state creep rate of a PM NiAl alloy with a dispersion-strengthened structure formed by rapid powder compaction is about 1.5 order of magnitude less than that of a cast NiAl alloy. This is explained by the high stability of the dispersion-strengthened structure. The apparent activation enthalpy for the creep of PM NiAl is 560 kJ/mol at 1100-1200 C, which is attributed to processes occurring in the disperse grain-boundary oxide phase.

A87-43642 Strength and damage characteristics of ceramic-matrix carbon composites (Prochnost' i povrezhdaemost' ugleirodnykh kompozitsionnykh materialov s keramicheskoi matritsei) E. A. ESKIN, G. P. KHRISTOV, A. S. PETROV, V. K. FEDCHUK, and A. V. IZOTOV, *Problemy Prochnosti* (ISSN 0556-171X), no. 5, May 1987, pp. 80-84. 11 Refs.

An experimental study is made of the effect of a high-temperature oxidizing medium on the load-bearing capacity of ceramic-matrix composites reinforced by carbon fabric with and without a heat-resistant coating. Changes in the load-bearing capacity, strength, and damage of the materials tested are related to the time of exposure to the high-temperature oxidizing medium. It is shown that oxidation starts with the carbon fibers and that there is a linear relationship between the thickness of the oxidized layer and the heating time.

A87-25183 Thermoelasticity problem for a unidirectional fiber composite subjected to pulsed thermal loading (Zadacha termoprugosti odnonapravlenogo voloknistogo kompozita pri impul'snom temperaturnom vozdeistvii) V. V. VOROBEL, I. A. IVANOV, L. P. KHOROSHUN, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 22, Oct. 1986, pp. 86-91.

The paper is concerned with the problem of the pulsed thermal loading of a layer reinforced by transverse unidirectional fibers. The time dependences of temperature on the opposite side of the layer are determined on the basis of two-parametric theory and by using the method of effective constants. The applicability of the pulsed method to the determination of the thermophysical properties of composite materials is investigated. The mean component stresses are determined by using coupled thermoelasticity equations.

A87-25154 Thermal deformation and the high-temperature strength of composite materials (Teplovoe deformirovanie i prochnost' kompozitnykh materialov pri vysokikh temperaturakh) G. N. TRETIACHENKO and L. I. GRACHEVA, *Mekhanika Kompozitnykh Materialov* (ISSN 0203-1272), Sept.-Oct. 1986, pp. 800-805. 8 Refs.

The thermodynamic relationships between specific heat and thermal expansion (compression) coefficient are examined for the case of non-metallic degradable composites. For the uniaxial stressed state, a relationship is established between the temperature coefficient of linear expansion, α , and the elastic characteristics of composites. It is shown that the value of α depends not only on the composite structure but also on the composite fabrication process (e.g., heating conditions and the gas medium composition). It is further shown that, in the case of polymer and carbon composites subjected to purely thermal loading, the reliability of the calculated strength of composite structures increases as test conditions approach actual operating conditions.

A87-24460 Thermophysical properties of a copper-graphite material at high temperatures (Teplofizicheskie svoistva mednografritovogo materiala pri vysokikh temperaturakh) A. N. KVASHA, O. N. SEMCHENKO, S. K. SENOTRUSOV, K. M. KONSTANTINOV, and O. P. ZHELEZNIK, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 24, Sept.-Oct. 1986, pp. 1029-1031. 5 Refs.

A study is made of the thermophysical properties of a high-density (6.4 g/cu cm) sintered antifriction material based on PMS-2 copper powder with 10 percent of S-2 colloid graphite. It is shown that the final structure of the sintered material is a heterogeneous system with interdiffused components and closed inclusions. The existing generalized conductivity equations make it possible to calculate the effective thermal conductivity of the antifriction material in the temperature range 20-800 C with an accuracy to within plus or minus 20 percent.

A87-24400 The interaction of titanium carbides and carbonitrides with nickel intermetallics (Vzaimodelstvie karbida i karbonitrida titana s nikelidami) V. S. PANOVA, A. V. TUMANOV, and I. F. KOTS, *Poroshkovaia Metallurgii* (ISSN 0032-4795), Oct. 1986, pp. 81-84. 8 Refs.

The paper is concerned with the wettability and solubility of titanium carbides (carbonitrides) in nickel intermetallics. It is found that good wettability of the refractory base by nickel intermetallics in hydrogen is observed in the systems Ti(C, N)-Ni₃Al(NiAl) and TiC-Ni₃Al(NiAl). It is further found that nickel intermetallics diffuse into the substrate along the carbide and carbonitride grain boundaries to a depth of 10-50 microns. The solubility of titanium carbides and carbonitrides in Ni₃Al (hardened from 1500 C) is approximately 1.1 and 0.4 percent respectively, which is consistent with microhardness data for the corresponding solid solutions. Only one phase transition, the melting of a fusible phase based on Ni₃Al and NiAl, is identified in the systems investigated.

A87-21652 The nature of intergranular layers in a high-strength cast steel (O kharaktere mezhzernnykh prosloek v litoi vysokopropchnoi stali) S. K. GINZBURG, A. N. DANILOV, and N. V. DEGTIAREVA, *Akademiia Nauk SSSR, Izvestiia, Metally* (ISSN 0568-5303), Sept.-Oct. 1986, pp. 110-115. 10 Refs.

The composition and structural state of nonmetallic interlayers at the primary grain boundaries in castings of a maraging steel, 08N6G4ML, are investigated experimentally using transmission and scanning electron microscopy and electron probe microanalysis. It is found that the nonmetallic interlayers, which are responsible for local intergranular fracture and a deterioration of mechanical properties, consist of completely or partially amorphous film inclusions. They are formed during casting and heat treatment as segregations containing metals (Fe, Ni, Mn, and Mo) and metalloids (Si and P) and may be classified as amorphous alloys.

A88-11227 Creep behavior of a coated niobium alloy under stepped changes in stress and temperature (Polzuchest' niobievogo splava s pokrytiem pri stupenchatom izmenenii napriazheniia i temperatury) I. A. EREMIN, L. V. KADALOVA, P. B. KUZNETSOV, and O. V. TSYGULEV, *Problemy Prochnosti* (ISSN 0556-171X), Aug. 1987, pp. 50-53. 7 Refs.

Plane specimens of a niobium alloy, with and without a thermally sprayed protective coating, were tested in creep at three levels of stress (30, 40, and 50 MPa) and temperature (900, 1150, and 1400 C). The rheological behavior of the specimens is analyzed by representing creep strains in the form of a sum of components each of which is described by a system of finite and ordinary differential equations. The equations are shown to provide an adequate description of the experimentally observed creep behavior of the alloy.

A87-51116 Physicomechanical properties of IV-V metal diborides sintered at high pressure (Fizikomekhanicheskie svoistva diboridov metallov IVa, Va grupp, spechennykh pri vysokom davlenii) A. M. MAZURENKO, V. S. URBANOVICH, and T. I. LEONOVICH, *Poroshkovaia Metallurgii* (ISSN 0032-4795), July 1987, pp. 37-40. 10 Refs.

The paper is concerned with the sinterability of diborides of IV-V transition metals (e.g., TiB₂, ZrB₂, HfB₂, NbB₂, and TaB₂) and physicomechanical properties of diboride compacts sintered at high pressures. It is found that the micromechanical properties (microhardness, microbrittleness, and microstrength) of the compounds studied depend not only on the rms displacements of lattice elements but also on the microstructure. The formation of a fine-grained structure during high-pressure sintering results in improved ductility of the sintered material.

A87-39209 A study of the precipitation hardening of chromium by titanium, zirconium, and hafnium carbides (Issledovanie dispersnogo uprochneniia khroma karbidami titana, tsirkoniia i gafniia) V. N. GRIDNEV, O. I. BAN'KOVSKII, V. G. IVANCHENKO, and V. V. POGORELAIA, *Metallfizika* (ISSN 0204-3580), Vol. 9, Mar.-Apr. 1987, pp. 18-22.

The high-temperature strength of cast chromium alloys hardened by Ti, Zr, and Hf carbides is investigated using the continuous hardness method. It is found that the precipitation-hardened chromium alloys retain a high hardness up to temperatures equal to 0.6 of the melting temperature of Cr. At temperatures up to 0.4 of the melting temperature, maximum hardness is observed in eutectic alloys, which is explained by the formation of a framework of a refractory carbide component.

A87-39105 A study of the gamma prime phase in a nickel alloy after the substitution of boron for carbon and during prolonged aging (Issledovanie gamma-prime-fazy v nikel'evom splave pri zamene ugleroda borom i dliatel'nom starenii) A. A. KOPYLOV, V. A. KOPYLOVA, V. V. BOGAEVSKII, and V. V. KISELEV, *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 62, Dec. 1986, pp. 1175-1180.

A study is made of changes in the chemical composition and some characteristics of the gamma prime phase in a precipitation-hardenable nickel alloy resulting from the addition of 2Bmron and prolonged high-temperature exposure. It is shown that the temperature of the complete dissolution of the gamma prime phase is largely determined by the total content of aluminum and titanium in this phase. The thermal effect of maximum ordering and the intensity of superstructural reflexes of the gamma prime phase depend only on the amount of Ni and Al; the lattice spacing is controlled primarily by Ti content.

A87-39093 High-temperature oxidation mechanism of EP648-VI alloy (Mekhanizm vysokotemperaturnogo oksleniia splava EP648-VI) E. M. LAZAREV, L. A. MONAKHOVA, A. T. KOZLOV, I. V. ROMANOVICH, and Z. I. KORNILOVA, *Akademiia Nauk SSSR, Izvestiia, Metally* (ISSN 0568-5303), Mar.-Apr. 1987, pp. 174-180.

The mechanism of the high-temperature oxidation of EP648-VI, a high-chromium nickel alloy, is investigated experimentally in the temperature range 1000-1200 C. It is found that the oxidation mechanism involves chromium diffusion in the oxide lattice, oxygen counterdiffusion at the oxide grain boundaries and microcracks, and the evaporation of chromium, tungsten, and molybdenum oxides. The scale on EP648-VI alloy consists mainly of alpha-Cr₂O₃ and is susceptible to cracking due to high compressive stresses. The protective properties of the scale are associated with the presence of cracks and a thin surface layer of NiCr₂O₄ spinel.

A87-35883 Formation of point defects and thermophysical properties of nickel at high temperatures (Obrazovanie tochechnykh defektov i teplofizicheskie svoistva nikelia pri vysokikh temperaturakh) S. I. U. GLAZKOV, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 25, Jan.-Feb. 1987, pp. 59-64. 44 Refs.

The temperature coefficient of linear expansion, the specific heat, and the temperature coefficient of electrical resistance of commercially pure nickel (99.5 pct Ni) are determined experimentally in the temperature range 900-1400 K. The results of the measurements are then analyzed in relation to the formation of equilibrium point defects. The enthalpy of the formation of point defects is determined to be equal to 1.4 plus or minus 0.2 eV.

A87-34349 High-temperature creep of Mo-Nb single-crystal alloys (Vysokotemperaturnaya polzuchest' monokristallicheskiy spлавov Mo-Nb) N. G. TACHKOVA, P. V. ZUBAREV, A. A. IASTREBKOV, N. G. AFANASEV, and V. A. REPII, *Akademiia Nauk SSSR, Izvestiia, Metall* (ISSN 0568-5303), Jan.-Feb. 1987, pp. 153-157. 12 Refs.

The creep behavior of Mo-Nb single crystals containing up to 11 pct Nb is investigated experimentally at 1500, 1650, 1800, and 1900 C in vacuum in the tensile stress range 5-50 MPa. In the temperature and stress ranges investigated, the alloying of molybdenum single crystals with Nb significantly increases the creep resistance of the material. The effect of Nb is particularly pronounced at concentrations less than 3 percent. Thus, an Nb addition of 1 percent produces a factor of 10 decrease in creep rate. The mechanisms responsible for the increase in creep resistance are examined.

A87-31967 Structural changes in the surface layers of self-bound silicon carbide during high-temperature friction (Strukturnye izmeneniia v poverkhnostnykh sloiakh samosviazannogo karbida kremniia pri vysokotemperaturnom trenii) I. U. G. TKACHENKO, A. N. PILIANKEVICH, V. F. BRITUN, V. D. BAZILEVICH, and N. F. OPANASHCHUK, *et al. Poroshkovaia Metallurgii* (ISSN 0032-4795), Jan. 1987, pp. 74-81. 8 Refs.

The friction coefficients and wear rates of SiC-SiC pairs are determined experimentally as a function of temperature during friction in air and in vacuum at an average sliding velocity of 0.01 m/s and a normal load of 1 MPa. Minimum wear and friction coefficients are observed in the temperature range 300-400 C. The structure formed in the surface layer of the specimens during friction is studied by electron microscopy, and the mechanisms controlling the microplasticity of SiC during low- and high-temperature friction are identified.

A87-31963 The structure of hot-pressed materials in the system sialon-refractory compounds (Struktura gorachepressovannykh materialov v sisteme sialon-tugoplavkie soedineniia) O. V. BAKUN, O. N. GRIGOREV, G. G. GNESIN, I. U. N. IVASHCHENKO, and V. V. KOVYLIAEV, *et al. Poroshkovaia Metallurgii* (ISSN 0032-4795), Jan. 1987, pp. 45-48. 5 Refs.

An experimental study is made of structure formation processes in the system sialon-TiN during hot pressing at 1900-2100 K, 300 MPa. It is found that the synthesis of a ceramic material in this system involves intense chemical interactions and the formation of a complex heterophase system in which practically all identified phases are solid solutions. This contributes to the formation of phase boundaries that are characterized by high strength and a low level of internal stresses.

A87-26307 The effect of temperature, protective coatings, and service history on the fatigue strength of gas-turbine engine blades made from the high-temperature cast alloy EP539LM (Vliianie temperatury, zashchitnykh pokrytii i ekspluatatsionnoi n rabotki na soprotivlenie ustalosti rabochikh lopatok GTD iz liteinogo zharoprochnogo splava EP539LM) V. I. ROMANOV, B. A. GRIAZNOV, A. A. RABINOVICH, O. G. ZHIRITSKII, and I. S. MALASHENKO, *et al. Problemy Prochnosti* (ISSN 0556-171X), Nov. 1986, pp. 47-52.

A procedure for the fatigue testing of the blades of gas-turbine engines at high temperatures and loading frequencies is described with particular reference to blades made from the high-temperature cast alloy EP539LM with various protective coatings. The heating of test specimens is done by high-frequency current; mechanical loading is carried out using an electrodynamic excitation and high-Q oscillatory systems. It is shown that, as a rule, protective coatings somewhat reduce the fatigue strength of the alloy, with the exception of slurry-diffusion Al-Si coatings. Optimum overall protection, however, is provided by a multicomponent electron-beam Co-Cr-Al-Y coating.

A87-31883 Premartensitic anomalies of elastic properties and internal friction in single crystals and polycrystals of TiNi (Predmartensitnye anomalii uprugikh svoistv i vnutrennee trenie v mono- i polikristallakh TiNi) S. A. MUSLOV, V. N. KHACHIN, V. P. SIVOKHA, and V. G. PUSHIN, *Metallofizika* (ISSN 0204-3580), Vol. 9, Jan.-Feb. 1987, pp. 29-32, 42. 14 Refs.

The elastic properties and internal friction characteristics of single crystals and polycrystals of Ti-51.0 at. pct Ni alloy are investigated over a wide temperature range preceding martensitic transformations (B2-R-B19 prime). It is found that anomalies in the elastic properties of the alloy are observed at least 550-650 K below the B2-R transformation; these anomalies become more pronounced near the martensitic transformation region, with the elastic properties of the lattice being nearly isotropic. Premartensitic internal friction is anisotropic, with a maximum in the shear basis system. The high-temperature (about 850 K) internal friction peak is shown to be of grain boundary origin.

A87-29881 Kinetic characteristics of the high-temperature oxidation of commercial titanium alloys (Kineticicheskie zakonomernosti vysokotemperaturnogo okisleniia promyshlennykh titanovykh spлавov) G. G. MAKSIMOVICH, V. N. FEDIRKO, and A. T. LIZUN, *Fiziko-Khimicheskaia Mekhanika Materialov* (ISSN 0430-6252), Vol. 22, Nov.-Dec. 1986, pp. 76-80. 15 Refs.

The oxidation behavior of titanium alloys and the effect of alloying elements on their heat resistance in air at 650-1000 C are examined with reference to experimental results obtained for a series of commercial titanium alloys, including VT1-0, Ti-2Al, PT7M, OT4-1, VT5, VT6s, VT14, and VT23. In the temperature range 650-750 C, the oxidation of the alloys studied is described by a parabolic law. At higher temperatures, there is a tendency towards linear oxidation kinetics due to the cracking of the oxidation layer. Al, Mo, Zr, and Sn increase the heat resistance of the alloys in the range 650-750 C; at 850 C this effect is produced by Al, Mo, and Zr, and at 1000 C by Al and Mo only. Of the alloys studied, VT5, VT5-1, PT7M, and particularly VT14 have the highest oxidation resistance. (V.L.)

A87-29206 Characteristics of the deformation and fracture of a hot-pressed tungsten-copper pseudoalloy at high temperatures (Zakononomernosti deformirovaniia i razrusheniia gorachepressovannogo vol'fram-mednogo psevdosplava pri vysokikh temperaturakh) V. K. KHARCHENKO, N. V. SKRIPNIK, and I. U. L. PILIPOVSKII, *Problemy Prochnosti* (ISSN 0556-171X), Dec. 1986, pp. 56-62. 16 Refs.

The short-term strength characteristics of a hot-pressed tungsten-copper pseudoalloy are investigated experimentally with allowance for their composition over a wide temperature range (20-2750 C). It is found that there is a statistically significant dependence of the strength and percent elongation of the pseudoalloy on its density in the temperature range 500-2500 C. The temperature dependences of the strength characteristics of W-Cu pseudoalloys are investigated in relation to fracture micromechanisms. The effect of copper evaporation prior to testing and of tungsten powder properties on the strength and ductility characteristics of the pseudoalloy is examined over a wide temperature range.

A87-28457 The creep rate of molybdenum and nickel at 0.56 of the melting temperature (Skorost' polzuchesti molibdena i nikelia pri 0.56 Tpl) I. V. MOISEVA, P. N. OKRAINETS, and V. K. PISHCHAK, *Akademiia Nauk SSSR, Izvestiia, Metall* (ISSN 0568-5303), Nov.-Dec. 1986, pp. 180-184. 10 Refs.

The creep behavior of zirconium-refined polycrystalline molybdenum and of polycrystalline nickel are investigated at 1360 and 700 C, respectively, which corresponds to 0.56 of the melting temperature. At high stresses, both Mo and Ni exhibit equally high sensitivity of the creep rate to stress. At low stresses, a linear dependence of the creep rate on strain is observed in molybdenum, while nickel exhibits creep with $n = 4.5$. It is noted that the mechanism of creep in molybdenum at 0.56 of the melting temperature needs to be further investigated.