

# Russian and Japanese Aerospace Literature

During 1996 the *AIAA Journal* will carry selected abstracts on leading research topics from Russian aerospace literature and, as space permits, from similar Japanese literature. The topics will be chosen and the abstracts reviewed for pertinency by *AIAA Journal* editors. This month features Titanium Alloys from Russia and Crack Propagation from Japan.

Support for assembling and publishing the selected abstracts has been provided by the Innovative Science and Technology Directorate of the Strategic Defense Initiative Organization (SDIO), with the sponsorship and technical management of the abstract service by the Office of Naval Research (ONR) under ONR Grant N00014-93-I-1074.

Abstracts in this listing have been taken from the monthly abstract journal *International Aerospace Abstracts* (IAA), published by the American Institute of Aeronautics and Astronautics (AIAA). Additional materials can be obtained through searching the Aerospace Database—available online via DIALOG or NASA RECON.

Paper copies and microfiche of the original documents cited are available from Aeroplus Dispatch, 1722 Gilbreth Road, Burlingame, CA 94010 (800) 662-2376. Use the "A" number to identify material you want. Please be advised that most of the original documents are in the original language. Direct questions concerning this abstract section of the *AIAA Journal* to Norma Brennan at AIAA Headquarters.

## Russian Aerospace Literature This month: *Titanium Alloys*

**N95-24541 JPRS report: Science and technology. Central Eurasia.**  
p. 41. Documents available from Aeroplus Dispatch.

Translated articles cover the following topics: problems of constructing welded aircraft structures; automatic welding of aluminum and titanium alloy structures; fusion welding thin-sheet titanium alloys to corrosion-resistant steels; and reconditioning aircraft parts with laser-fused hard-facing coatings (Author)

**A95-35410 Self-propagating high-temperature synthesis in the production of functionally gradient material.** A. G. MERZHANOV, A. N. PITYULIN (Russian Academy of Sciences, Inst. of Structural Macrokine- tics, Chernogolovka, Russia), *FGM 94; Proceedings of the 3rd International Symposium on Structural and Functional Gradient Materials*, Swiss Federal Inst. of Technology, Lausanne, Switzerland, 1994 (A95-35401 09-23), Lausanne, Switzerland, Presses Polytechniques et Universitaires Romandes, 1995, pp. 87-94. 21 Refs. Documents available from Aeroplus Dispatch.

The high efficiency of self-propagating high-temperature synthesis (SHS) as applied to the production of functionally gradient materials (FGM) has been demonstrated in the studies of Japanese, Russian, Chinese, and American scientists. Essentially, three different schemes have been developed so far: 1) a gradient green charge, in which gradient materials are synthesized from the green charge gradient in its composition, 2) a bi-layer green charge, in which a gradient structure is formed from the bi-layer green charge with a fused layer controllably impregnating the other to result in product densification, and 3) a uniform green charge, in which a used uniform green charge forms a high-temperature multicomponent melt yielding a gradient structure with control over the completeness of phase separation. The former scheme has been proposed by Japanese scientists, the other two have been developed in Russia. Sometimes more complicated schemes are used. Hard alloys (TiC-Ni, TiB<sub>2</sub>-Ti, TiB<sub>2</sub>-Al, TiB<sub>2</sub>-Cu, and the like), intermetallics (NiAl, TiNi, TiAl, and the like), and ceramic minerals (a metal or a refractory compound, such as Al<sub>2</sub>O<sub>3</sub>) are among the most often produced FGM. In an analytical survey of studies concerning SHS of FGM, the problems of SHS mechanisms resulting in the FGM formation were considered and the influence of physical (mechanical, ultrasonic, electromagnetic) treatment on the structural transformations during SHS of FGM was determined. (Author)

**A95-35309 Quantitative neutron diffraction phase analysis of hydrogenated VT6 titanium alloys (Nejtronoigraficheskij kolichestvennyj fazovyj analiz gidrirovannykh titanovykh spлавov VT6).** V. E. ARKHIPOV, S. F. DUBININ, V. E. NAJSH, T. V. NOVOSELOVA, S. B. PUPYSHEV, N. P. RATSLAV, I. V. SAGARADZE, and S. G. TEPLOUKHOV (RAN, Inst. Fiziki Metallov, Yekaterinburg, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 78, No. 5, 1994, pp. 147-155. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

The relative contents of the plasticizing cubic beta phase and of the stoichiometric hydride TiH<sub>2</sub> in hydrogenated VT6 titanium alloy are determined as a function of temperature and hydrogen content. The conditions of alloy dehydrogenation under heating is investigated. The effect of hydrogen ordering in the hexagonal alpha phase of the alloy is observed, and a model of the corresponding superstructure is presented. The temperature conditions leading to such ordering are determined.

**A95-35306 Formation and structure of phases precipitating in titanium and zirconium alloys (Obrazovanie i struktura faz, vyzhayushchikhsya v splavakh titana i tsirkoniya).** V. A. VOZILKIN and T. L. TRENOGINA (RAN, Inst. Fiziki Metallov, Yekaterinburg, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 78, No. 5, 1994, pp. 19-28. In Russian. 32 Refs. Documents available from Aeroplus Dispatch.

The structure and mechanisms of phase formation in titanium and zirconium alloys which significantly affect the alloy properties are investigated with reference to original research and data in the literature. The sequence and conditions of the precipitation of alpha and omega phases are examined as a function of the alloying element concentration. Data are presented on beta matrix ordering with the formation of the B<sub>2</sub> structure in Ti-Nb-Al alloys and its decomposition with the precipitation of ordered alpha-0 phase during subsequent anneals.

**A95-35302 Phase transformations in austenitic Fe-Ni and Fe-Ni-Ti alloys under low-temperature electron irradiation (Fazovyie prevrashcheniya pri nizkotemperaturnom obлучenii ehlektronami v avstenitnykh Fe-Ni i Fe-Ni-Ti splavakh).** V. V. SAGARADZE, V. A. SHABASHOV, T. M. LAPINA, and V. L. ARBUZOV (RAN, Inst. Fiziki Metallov, Yekaterinburg, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 78, No. 4, 1994, pp. 88-96. In Russian. 15 Refs. Documents available from Aeroplus Dispatch.

By using Mossbauer spectroscopy, it is shown that the alloying of Fe-Ni invar austenite by titanium (2.6 mass percent) changes the type of radiation-induced phase transformation during low-temperature (393-473 K) irradiation by electrons. In particular, the segregation of the fcc solid solution is replaced by intermetallic aging with the precipitation of a high-nickel phase. Prior strong plastic deformation is shown to accelerate the diffusion equilibrium processes of intermetallic aging the Ti-alloyed and to inhibit solid solution segregation with respect to nickel in the binary alloy.

**A95-33484 Effect of the rolling direction on the strength and ductile characteristics of wide sheets of PT-3Vkt alloy (Vliyanie napravleniya prokatki na kharakteristiki prochnosti i plastichnosti 'shirokikh' listov splava PT-3Vkt).** A. A. BRYUKHANOV, A. R. GOKHMAN, and Y. G. MIKHAILOVSKIY (Odesskij Pedagogicheskij Inst., Odessa, Ukraine), *Problemy Prochnosti* (ISSN 0556-171X), No. 6, 1994, pp. 72-77. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

A study is made of the orientation dependence of the mechanical properties of a Ti-Al-V alloy, PT-3Vkt, after warm transverse rolling followed by cold rolling. Fourier series are obtained for describing the anisotropy of each property based on the experimental data and a strength criterion which allows for the effect of hydrostatic pressure on the material strength. Correlations are established between the physical and mechanical properties of the material.

**A95-33098 Estimating the cyclic fracture toughness of smooth specimens of VT-20 titanium alloy (Otsenka tsiklicheskoy treshchinostojkosti gladkikh obraztsov titanovogo splava VT-20).** O. L. GOLUBOVA, *Metally* (ISSN 0869-5733), No. 2, 1995, pp. 139-144. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

A method is proposed for determining the crack size from measurements of the maximum cycle stress during thermal fatigue testing under loading

at constant transverse strain amplitude. Analytical expressions are obtained which relates the specimen geometry and type of loading to the fatigue crack size. An expression is also presented for determining the stress intensity factor along the entire length of a fatigue crack under axial tension/compression.

**A95-32745 Hot oxidation resistance of an intermetallic Nb-Ti-Al alloy.** O. A. BANNYKH, E. N. SHEFTEL, G. S. USMANOVA, and A. A. SHARAPOV (Russian Institute of Sciences, Inst. of Metallurgy, Moscow, Russia), *High-temperature ordered intermetallic alloys VI; Proceedings of the Symposium*, Boston, MA, 1994. Pt. 2 (A95-32604 08-26), Pittsburgh, PA, Materials Research Society (MRS Symposium Proceedings. Vol. 364), 1995, pp. 969-974. 7 Refs. Documents available from Aeroplus Dispatch.

Structure, phase composition and air oxidation behavior in the temperature range 800-1400 C of a Nb-Ti-Al-based intermetallic alloy with the chemical composition (wt%): Nb-47.0; Ti-23.9; Al-21.0, V-4.4, and Cr-4.1 have been studied. The alloy structure is two-phase-sigma (Nb<sub>2</sub>Al type) and gamma (TiAl type). Preliminary air oxidation at 1400 C decreases the oxidation rate at 1150 C by a factor 2-3; it is connected with the formation of a protective scale (rutile and corundum with chromium and vanadium additions), refining of the alloy structure, and the formation of an internally oxidized underscale. (Author)

**A95-26015 Metallurgical and technological aspects of titanium alloys application for helicopter industry.** M. G. VEITSMAN (Mil Moscow Helicopter Plant, Russia), *20th European Rotorcraft Forum*, Amsterdam, Netherlands, 1994. Proceedings. Vol. 4 (A95-25916 06-01), Amsterdam, Netherlands, National Aerospace Laboratory, 1994, pp. 110-2-110-11. Documents available from Aeroplus Dispatch.

The paper gives information on titanium alloys used in helicopters developed by the Mil Moscow Helicopter Plant, shows different principles of technology used for manufacturing of forgings on metallurgical and of parts on machine-building plants, and presents data indicating their quality level. Special attention is given to the development of specific quality control methods for components and half-finished products which assure their high quality and long service life. (Author)

**N95-12001 JPRS report: Science and technology. Central Eurasia.** p. 130. Documents available from Aeroplus Dispatch.

Translated articles cover the following topics: boronizing laser treatment of titanium alloys; argon-arc welding on titanium dowels to inserts for aircraft structures made of composite materials; method of reducing level of thermally stressed state of gas turbine engine blades by selecting optimum thickness distribution of ceramic heat shield coating; certifying modern ceramics for mechanical properties; superplastic ceramic: possibilities for application in modeling pressworking manufacturing processes; monitoring strength of ceramics by acoustic emission; physical and mechanical properties of Al<sub>2</sub>O<sub>3</sub> + ZrO<sub>2</sub>:Y<sub>2</sub>O<sub>3</sub> composite produced by directional crystallization from melt; influence that microalloying with rare earth elements has on resistance of steels to deformation and fracture under alternating elastic-plastic loading; conceptions of constructing information management networks for distributed objects; concept of a document information system based on an object-oriented subject-area model; underground future of rocket technologies; geoinformation approach to organizing automated information systems for regional-local monitoring of atmospheric pollutants; and possibility of using lidar wind sounding in climatic-ecologic monitoring of limited areas.

**A95-23763 Calculation of the heat/vibration hardening of aviation materials under conditions of stress relaxation (Raschet termovibratsionnogo uprochneniya aviatsionnykh materialov v usloviyakh relaksatsii napryazheniya).** G. V. VASIL'EV and Y. P. KATAEV (Kazanskij Gosudarstvennyy Tekhnicheskij Univ., Kazan, Russia), *Aviatsionnaya Tekhnika* (ISSN 0579-2975), No. 3, 1994, pp. 65-71. In Russian. 14 Refs. Documents available from Aeroplus Dispatch.

Based on a thermodynamic equation of thermoelastoplasticity and dissipation work under creep, used as a measure of hardening, an equation is obtained for determining the internal stresses accumulated during dynamic relaxation, which increase the resistance of the material to subsequent creep. The relaxation is described by a power law version of the hardening equation. The calculation results are compared with experimental data for EI698VD and VT16 alloys and beryllium.

**A95-23086 Determining the sites occupied by alloying element atoms in the gamma-TiAl lattice (K voprosu ob opredelenii pozitsij, zanimayemykh atomami legiruyushchikh ehlementov v kristallicheskoy reshetke gamma-TiAl).** O. A. BANNYKH, G. S. BRASLAVSKAYA, K. B. POVAROVA, and E. B. RUBINA, *Metally* (ISSN 0869-5733), No. 6, 1994, pp. 137-143. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

The solubility of vanadium in titanium aluminides is investigated metallographically, by X-ray diffraction, and electron probe microanalysis. The shape of the (Ti<sub>3</sub>Al-TiAl)/TiAl interface in the composition region up to 10 at.% V at 1000 C indicates that titanium sites are the preferred substitutional sites for vanadium atoms. The results do not support data in the literature concerning vanadium substitution at aluminum sites.

**A95-22725 The electrical resistivity of Ni<sub>3</sub>(Al,Ti)-C alloys.** B. V. NIKOLAEV and G. V. TYAGUNOV (Ural State Technical Univ., Yekaterinburg,

Russia), *Zeitschrift fuer Metallkunde* (ISSN 0044-3093), Vol. 85, No. 12, 1994, pp. 852-854. 7 Refs. Documents available from Aeroplus Dispatch.

Temperature and concentration dependences of electrical resistivity for Ni<sub>3</sub>(Al,Ti)-C alloys were investigated. It was shown that alloy disordering starts long before the melting point. In the liquid state, the resistivity hysteresis was discovered. The hysteresis is connected with the transition of melt from the unstable to the stable state. The hysteresis cause is the destruction of clusters which are inherited from solid state. (Author)

**A95-20122 A study of the reversible shape memory effect in thermomechanically and heat treated Ti-Ni-based alloys (Issledovanie obratimogo ehffekta zapominaniya formy v termicheski i termomekhanicheski obrabotannykh splavakh na osnove Ti-Ni).** I. Y. KHMELEVSKAYA, M. I. LAGUNOVA, S. D. PROKOSHIN, and L. M. KAPUTKINA (Moskovskij Inst. Stali i Splavov, Moscow, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 78, No. 1, 1994, pp. 83-88. In Russian. 5 Refs. Documents available from Aeroplus Dispatch.

The magnitude and stability of the reversible shape memory effect in Ti-Ni-based alloys are investigated as a function of the thermomechanical and heat treatment variables. The positive reversible shape memory effect is shown to have the highest thermal cycling stability in time. Alloys subjected to a high-temperature thermomechanical treatment are found to have the highest absolute value of reversible deformation.

**A95-18711 Mechanics of hot isostatic pressing in intermetallic matrix composites.** Y. A. BAHEI-EL-DIN (Cairo Univ., Giza, Egypt), G. J. DVO-RAK, and J. F. WU (Rensselaer Polytechnic Inst., Troy, NY), *Journal of Materials Science* (ISSN 0022-2461), Vol. 30, No. 1, 1995, pp. 1-23. 38 Refs. Documents available from Aeroplus Dispatch.

Thermal residual and mechanical stresses generated by HIPing, cooling, and subsequent mechanical loading of SCS<sub>6</sub>/Ni<sub>3</sub>Al and SCS<sub>6</sub>/Ti<sub>3</sub>Al composites with uncoated and carbon-coated fibers have been simulated by micromechanical modeling. The solutions were found in a periodic hexagonal array model of the microstructure using FEM. The intermetallic matrices were assumed to be elastoplastic, with temperature-dependent properties. The fiber and coating were assumed to be elastic. Local stress fields and overall response were found for several processing sequences. Plastic deformation of the matrix during cooling from fabrication temperatures reduces residual stresses. The Ni<sub>3</sub>Al matrix system yields more easily than the Ti<sub>3</sub>Al system. HIP programs that promote such yielding are proposed, and analyzed in both systems. Compliant and expansive fiber coatings tend to reduce the thermal stresses, but may also enhance the interface stresses in the matrix under overall mechanical loads.

**A95-16629 Effect of deformation on phase and structural transformations in VT23 titanium alloy (Vliyaniye deformatsii na fazovye i strukturnye prevrashcheniya v titanovom splave BT23).** O. M. IVASISHIN, V. V. MARTYNOV, A. V. TERUKOV, and A. V. TKACHENKO (ANU, Inst. Metallofiziki, Kiev, Ukraine), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 77, No. 5, 1994, pp. 83-88. In Russian. 11 Refs. Documents available from Aeroplus Dispatch.

It is shown that the deformation of the initial metastable beta phase in VT23 titanium alloy may be accompanied by the formation of orthorhombic alpha double prime martensite. The possibility of changing the symmetry of the martensite lattice from orthorhombic to hexagonal during deformation is examined.

**A95-16628 Effect of lattice relaxation on mixing energy and configuration interactions in alloys—Cluster calculations for diluted Ti(1-x)V(x) bcc alloys (Vliyaniye relaksatsii reshetki na ehnerguyu smesheniya i konfiguratsionnye vzaimodejstviya v splavakh—Klasternyye raschety dlya razbavlennykh OTsk splavov Ti(1-x)V(x)).** S. V. BEJDEN, V. G. VAKS, N. E. ZEJN, and G. D. SAMOLYUK (Inst. Obshchej i Yadernoj Fiziki, Moscow, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 77, No. 5, 1994, pp. 17-30. In Russian. 16 Refs. Documents available from Aeroplus Dispatch.

Results of self-consistent cluster calculations of the dissolution energy and configuration interaction constants, obtained by the LMTO-ASA method, are presented for Ti(1-x)V(x) bcc alloys. Lattice relaxation effects are described through the proper choice of atomic volumes for the impurity and its neighbors, which are estimated phenomenologically using the Khachatryan method. Results of phenomenological estimates of contributions of lattice relaxation energy to the dissolution energy are presented in a tabular form for impurities in 24 bcc metals.

**A95-16626 Structure of Ti-50 pct Nb-8 pct Al and Ti-65 pct Nb-8 pct Al-2 pct Cu alloys (Struktura splavov Ti-50 pct Nb-8 pct Al i Ti-65 pct Nb-8 pct Al-2 pct Cu).** V. A. VOZILKIN, T. L. TRENOGOVA, and V. N. DEREVYANKO (RAN, Inst. Fiziki Metallov, Yekaterinburg, Russia), *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 77, No. 4, 1994, pp. 80-85. In Russian. 6 Refs. Documents available from Aeroplus Dispatch.

The structure and phase composition of Ti-50Nb-8Al and Ti-65Nb-8Al-2Cu alloys were investigated experimentally using transmission electron microscopy and X-ray diffraction analysis. It is found that, for the same aluminum content (8%), the ordering of the beta matrix during hardening from 1150 C with the formation of the B<sub>2</sub> structure and its decomposition during subsequent anneals with the precipitation of the alpha-0 phase occur in a more active manner in the alloy with 50% Nb.