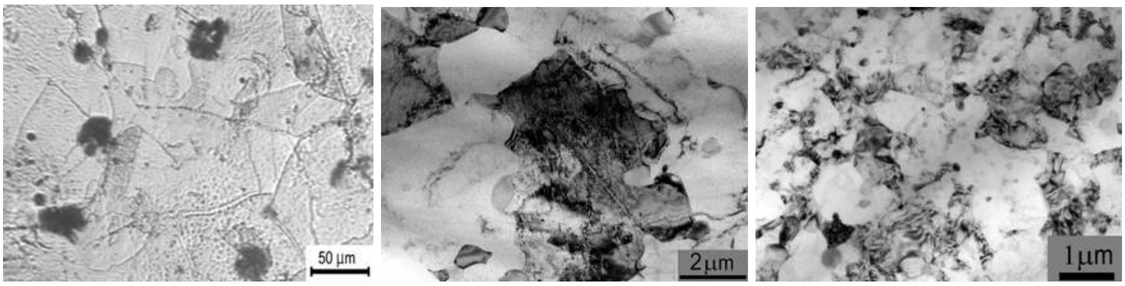


a *b* *c*

Figure 1. Microstructure after: a – annealing, b – ECAP, c - HPT

Results in Table summarize the mechanical properties of the alloy at room temperature. It is shown, that SPD processing is effective method for producing small grain size. And using different conditions of SPD processing can be possible to attain very high ultimate tensile strength up to 425 MPa without appreciable losing in ductility in comparison with alloy before SPD.

Table. Mechanical properties of AZ91D after different treatments

Material	Average grain size, µm	Yield stress, MPa	Ultimate tensile strength, MPa	Elongation, %
AZ91D, annealing.	> 100	95	150	6
AZ91D, ECAP	5	130	240	6
AZ91D HPT	1	330	425	3

Magnesium alloy AZ91D after ECAP showed thermal stability of microstructure up to temperature 300^{o}C. Taking into account the enhanced thermal stability of microstructure we carried out also tensile tests in elevated temperatures. As a result the maximum ductility of 220% has been demonstrated at temperature 300^{o}C and strain rate 1x10^{-3} c^{-1}.

[1] M.M. Avedesian, H. Baker (Eds.), ASM Specialty Handbook Magnesium and Magnesium Alloys, The Materials Information Society, Materials Park, OH, (1999)

Poster report

Influence of Equal Channel Angular Pressing on Corrosion Behaviour of Ultrafine-Graned Copper Received by Various Routes

N.A. Amirhanova[a], F.A. Amirhanova[b] and
Julia.B. Kutnyakova[a,1]

[a] Ufa State Aviation Technical University, 12 K. Marx St, Ufa 450000 Russia

[b] Baskir State University, Ufa, Frunze, 33, 450000

[1] kutnyakova@mail.rb.ru

The corrosion behavior of ultrafine-grained copper processed by severe plastic deformation, using equal channel angular pressing has been investigated in this work. The potentials without a current and polarization curve and the corrosion currents were investigated. After this research it is possible to make a conclusion that the corrosion behavior of these materials is connected to a UFG structure.

The corrosion behavior of UFG Cu processed by severe plastic deformation, using equal channel angular pressing by different routs: A1, A2, A4, A8, A12, B12, F12 in comparison with CG Cu has been investigated. Electrochemical measurements were carried out in 1M HCl, 3% NaCl, 1M H_2SO_4 solutions.

The corrosion potentials of Cu with UFG and CG structure were determined in these solutions. Values of corrosion potentials in mineral acids are presented in Table 1. The corrosion potentials of Cu in NaCl solutions has more positive value than corrosion potentials of Cu in HCl solutions.

One can reveal the following properties of corrosion behavior of Cu with UFG and CG structure: increase of number of passes results in shifting of corrosion potentials to the area of positive values. The corrosion potentials of Cu A12, Cu B12 in HCl solutions are identical

Table 1

Route	The corrosion potentials, V		
	HCl 1M	NaCl 3%	H_2SO_4 1M
A1	0,1368	0,1856	0,2662
A2	0,1380	0,2026	0,2671
A4	0,1587	0,2020	0,2717
A8	0,1640	0,1913	0,2854
A12	0,1286	0,1778	0,3008
B12	0,1290	0,1627	0,3048
F12	0,1540	0,1834	0,3324
K3	0,1200	0,1800	0,3088

The corrosion potentials of Cu in sulfuric acid solutions has more positive value than corrosion potentials of Cu in HCl solutions. It is connected to growth of oxide layers.

The corrosion current density was determined from potentiostatic polarizing curves. Fig. 1 shows the value of corrosion current density in HCl 1M and NaCl 3% solutions. The value of corrosion current density is increasing with increase the number of passes.

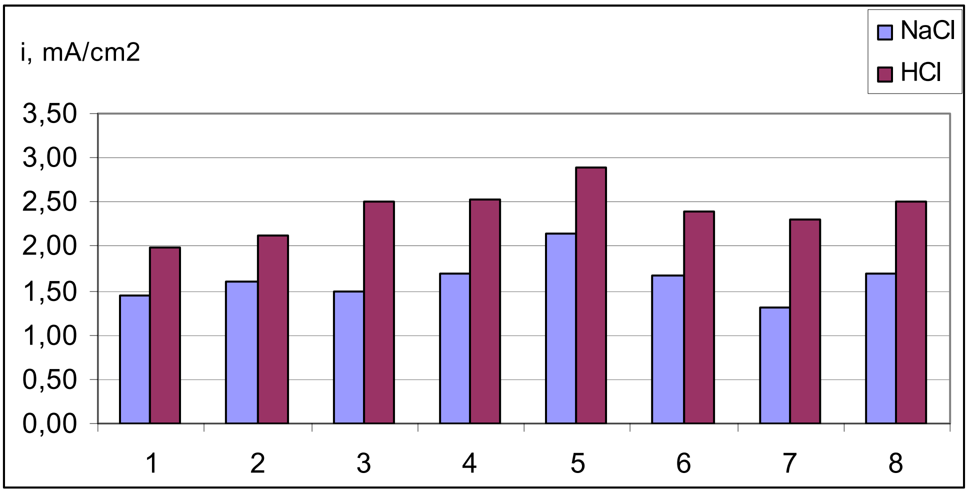


Figure 1. Corrosion current density in 3% NaCl and 1M HCl solutions. 1-A1, 2-A2, 3-A4, 4-A8, 5-A12, 6-B12, 7-F12, 8-CG Cu

The corrosion current of Cu in HCl has more values than it is in NaCl solutions.

The corrosion potentials of Cu depend on the material structure. UFG Ti has more positive significances of potentials than CG Cu.

The corrosion current density of UFG Cu A1-A8 is smaller than corrosion current density of CG Cu. And these values are practically identical for Cu B12, Cu F12 and CG Cu.

Poster report

Evolution of Mechanical Properties and Microstructure of CP Titanium with Initial Coarse-Grained and Nanocrystalline Structure during Cold Rolling

Svetlana Malysheva[a,1], Gennady Salishchev[a,2] and Evgenija Jakushina[b]

[a] Institute for Metals Superplasticity Problems, Russian Academy of Sciences,
39 Stepan Khalturin St., Ufa 450001, Russia

[b] Institute of Physics of Advanced Materials, Ufa State Aviation Technical University,
12 K. Marx St., Ufa 450000, Russia

[1] svufa@mail.ru, [2] gensal@anrb.ru

Investigations of materials processed by methods of severe plastic deformation (SPD) arise much interest in recent years. SPD methods provide essential structure refinement in various materials which results in their strength growth. Such methods as shear under pressure, equal channel angular pressing, and multiple step forging attract special interest among researchers. However, their industrial implementation is not always efficient since it requires application of special facilities and is often rather labor intense. The present attempt to attain large strains in commercial titanium via cold rolling is of much interest in terms of science and industrial implementation. The concurrent studies of titanium with initial nanocrystalline (NC) structure were used to determine the most efficient methods for increasing its mechanical properties.
The evolution of microstructure, texture and mechanical properties of commercial titanium during cold rolling has been studied. NC structure was processed in billets by means of multiple step forging. The processed microstructure is not uniform; its mean grain size is about 0.25 μm and the volume fraction of coarse grains having a size more than one micrometer is 30%.

It has been established that at rolling of sheets with both the initial NC and coarse-grained (CG) structures their structure undergoes refinement and becomes more uniform. After rolling of sheets with initial CG structure by 50% strain it is observed formation of submicron size grains fraction of which increases with strain. In sheets of both structures a typical rolling texture is formed.

The increase in rolling strain results in an essential growth of yield strength of titanium with CG structure while in titanium with NC structure yield strength remains almost the same. With increasing rolling strain up to 50% a value of ultimate strength grows and in the sheets with initial NC structure this value is higher than in the sheets with CG structure. However, after 50% strain this difference disappears. After rolling by 97% the ultimate strength of titanium with NC and CG structures is higher than 1000 MPa. At rolling up to 50% the ductility of sheets of both types does not change. However, the elongation of sheets with the initial CG structure is higher by 40% than the elongation of the sheets with the NC structure. The sheets with the initial CG structure display elongation anisotropy in the initial strain of rolling. In particular, after rolling by 25% the ductility of sheets cut along the direction of rolling decreases to the value of the ones with NC structure and remains unchanged until 75% strain. After rolling by 75% the ductility of all sheets does not depend on the direction of cutting. The elongation of sheets with the initial CG structure is still higher and is about 30%. At 97% rolling the ductility of both states being almost similar is about 5%. The strength of sheets with both structures are higher than the strength of NC titanium processed by ECA pressing.

The work was supported by Russian Foundation of Basic Researches, grants RFBR № 05-08-65396.

Poster report

Microstructure and Mechanical Behavior of Bulk Tungsten Processed by Severe Plastic Deformation

Suveen N. Mathaudhu[a,1], Q. Wei[b,2], Laszlo J. Kecskes[c,3], and K. Ted Hartwig[d,4]

[a] ORISE Post-Doctoral Fellow, U. S. Army Research Laboratory
Aberdeen Proving Ground, MD 21005 5069

[b] Department of Mechanical Engineering, University of North Carolina – Charlotte, Charlotte, NC 28223-0001

[c] U. S. Army Research Laboratory, Aberdeen Proving Ground, MD 21005 5069

[d] Department of Mechanical Engineering, Texas A & M University
College Station, TX 77843-3123

[1]Suveen.Mathaudhu@arl.army.mil, [2]Qwei@uncc.edu, [3]Kecskes@arl.army.mil, [4]Thartwig@tamu.edu

Recent studies on W have shown that ultrafine grained microstructures produced by severe plastic deformation (SPD) processing have properties quite different from their coarse-grained (CG) counterparts. In this experiment, pure, CG W was processed via multipass equal channel angular extrusion (ECAE) to refine the as-received microstructure and improve the high strain rate deformation properties. Up to four extrusion passes were done on encapsulated 12 mm diameter x 100 mm long W rods in tooling with a 90-degree channel intersection at a rate of 25 mm/s, near the recrystallization temperature of W. Electron microscopy (TEM and SEM), Vickers microhardness and quasi-static (~10-3 s-1) and dynamic (~103 s-1) uniaxial compression testing were used to examine the properties of the W extrudates. Microscopy analyses of the resultant samples showed elongated grains ~300-500 nm in size. Compared to conventional CG W, the SPD W showed a higher flow stress, enhanced ductility, reduced strain hardening capacity, and reduced strain-rate sensitivity. Compressive tests also demonstrated that the bulk deformation shifted from a typically strain and strain-rate hardening to a strain and strain-rate softening behaviour. These results and a survey of the microstructural features of the as-deformed samples are to be discussed.

Keywords: tungsten, microstructure, severe plastic deformation, ECAE, ECAP, hardness.

Poster report

Formation of Structure and Substructure during SPD

Victor Varyukhin[a], Boris Efros[a], Leonid Metlov[a], Natalia Efros[a] and Vladimir Ivchenko[b]

[a] Donetsk physics and technology institute of NAS of Ukraine,
72 R. Luxembourg St., Donetsk 83114, Ukraine

[b] Institute of Electrophysics of Ural of branch of Russia Academy of Science,
34 Komsomolskaya St., Ekaterinburg 620219, Russia

metlov@mail.donbass.com

Before nowadays, one assumes that grain structure plays main role in the formation of features of nanomaterials, and internal grain structure (substructure) is absent or don't play any noticeable role. But last experimental data did achieved by Field Ion Microscopic Methods (FIMM) show it isn't so. In result of executed investigations, in particular, it was established that in the Iridium after SPD nanocrystallite (NC) structure is formed (size of NC ≈ 20-30 nm) and in doing this structure defects are absent into NC, but after irradiation by ions the subnanocrystallite (SNC) structure is formed (size of SNC ≈ 3-5 nm) with defect in the bulk of SNC (fig.1). SNC structure was revealed as in the NC Nickel, so in the NC Cooper after SPD (size of SNC ≈ 3-15 nm). In doing this in the SNC Cooper one observes more large boundary region and ultradispersive SNCs are more disoriented [1].

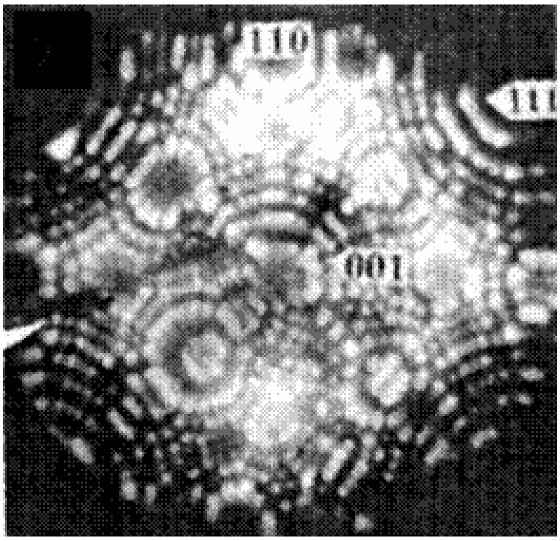


Figure 1. Field ion image of Iridium surface (V=10kV): UFG state after SPD (e ≈6)
(The arrows show the grain boundaries)

Nowadays, it is developed base of thermodynamic theory for description of processes of metal treatment by SPD methods, in what grain boundaries was considered as main structure defect, and one don't take into account possibility of explicit consideration of next structure level defects – boundaries of subgrain [2]. Concurrent taking into account grain and subgrain boundaries is effected by entering two dual pair of thermodynamic variables, one from which φ_g and h_g responses for formation of grain boundary structure, and other φ_s and h_s – subgrain boundary structure. Here φ_g, φ_s are surface energy densities, and h_g, h_s are bulk densities of total square of corresponded boundaries.

Thermodynamic identity for internal energy in this case may be written as:

$$du = \sigma_{ij} d\varepsilon_{ij}^{e} + Tds + \varphi_1 dh_1 + \varphi_2 dh_2 \qquad (1)$$

where u is density of internal energy, σ_{ij}, ε_{ij}^{e} are stress tensor and elastic part of deformation tensor, T, s are temperature and entropy.

Accounting of forth powers in free energy expansion on parameters φ_g and φ_s permits to regard its relief (fig.2) as function of droved parameters – elastic part of deformation tensor ε_{ij}^{e} and temperature T. Change of relief from two-well form to one-well form permits to treatment the transition from usual plasticity to SPD as phase transition of first kind, and coarse-grained structure of material as one from hierarchy of limited (stationary) structures.

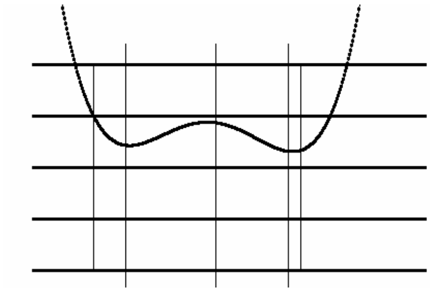


Figure 2. Two-wells free energy potential of model

[1] V. Varyukhin, B. Efros, V. Ivchenko, N. Efros and E. Popova, Rev. Adv. Mater. Sci., 10 (2005) 34

[2] L.S. Metlov, Deformation and Fracture of Materials, 2 (2007) 40

Poster report

Tribological Properties of Al-Sn, Al-Sn-Pb and Sn-Sb Alloys Subjected to Severe Plastic Deformation

Lev Korshunov[a,1], Nina Noskova[a,2], Alexander Korznikov[b,3]

[a] Institute of Metal Physics, Ural Division, Russian Academy of Sciences,
18 S. Kovalevskaya St., Ekaterinburg 620041, Russia.

[b] Institute of Problems of Metal Superplasticity Russian Academy of Sciences,
39 Khalturin St., Ufa 450001, Russia

[1]. korshunov@imp.uran.ru, [2] noskova@imp.uran.ru, [3] korznikova@anrb.ru

The friction coefficient and wear rate of Al-30%Sn, Al-5%Sn-35%Pb, and the manufactured babbitt of the B83 type (Sn-12%Sb-5.5%Cu) (wt.%) was subject to intensive plastic deformation by equal-channel angular pressing (ECAP) with a force of 40 tonne have been studied.

Tribological properties (wear rate and friction coefficient) of the materials in the initial (cast) and the deformed state were analyzed in conditions of sliding friction in air with 45 and X12M steels by pin-plate and pin-disk patterns. The pin (sample) – plate (steel 45, HRC = 50) tests were performed at the sliding speed of 0.07 m/s with and without the MS-20 lubricant. The normal load was 294 N and 980 N during dry and wet friction respectively. The pin (sample) – disk (X12M, HRC = 65) tests were performed at the sliding speed of 4.5 m/s with the I-30 lubricant at a load of 256 N.

The test results are given in the table. It is seen from the table that intensive plastic deformation don't have a positive effect on the tribological properties of Al-30%Sn, and Al-5%Sn-35%Pb (wt.%) alloys.

In the conditions of dry sliding friction at a slow speed, when the sample is worn by adhesion and is heated little by friction, the wear rate of the deformed babbitt is a factor of 1.5 larger than the wear rate of the cast babbitt. The wet tests (the boundary friction regime) at a slow sliding speed in the absence of considerable friction heating showed that the wear rate of the babbitt, which underwent intensive plastic deformation, is approximately 4 times smaller than the wear rate of the traditional cast babbitt. In the case of wet friction (the boundary friction regime) and intensive friction heating (the sliding speed of 4.5 m/s), the wear resistance of the babbitt, which was deformed by the ECAP method, is also considerably better (nearly 2 times) than the wear resistance of the cast babbitt. Moreover, the friction coefficient of the deformed babbitt is 1.6 times smaller than that of the cast material (see the table).

Table. The wear rate I_h *and the friction coefficient* f *of Al-30%Sn, Al-5%Sn-35%Pb alloys and the B83 babbitt in cast and deformed states*

Material, state	Dry pin-plate friction (V = 0.07 m/s, N = 294 N)		Pin-plate friction with MS-20 lubricant (V = 0.07 m/s, N = 980 N)		Pin-disk friction with I-30 lubricant (V = 4.5 m/s, N = 256 N)	
	I_h	**f**	**I_h**	**f**	**I_h**	**f**
Al-30%Sn						
Cast	$1.5 \cdot 10^{-7}$	0.33	$7.0 \cdot 10^{-8}$	0.03	$4.7 \cdot 10^{-10}$	0.04
Deformed	$1.0 \cdot 10^{-7}$	0.34	$8.0 \cdot 10^{-8}$	0.04	$1.1 \cdot 10^{-8}$	0.07
Al-5%Sn -35%Pb Cast						
Deformed	$2.1 \cdot 10^{-7}$	0.33	$1.2 \cdot 10^{-7}$	0.06	$1.4 \cdot 10^{-9}$	0.07
	$2.1 \cdot 10^{-7}$	0.35	0	0.05	$3.0 \cdot 10^{-9}$	0.07
Sn-12%Sb-5.5%Cu Cast						
Deformed	$1.4 \cdot 10^{-7}$	0.30	$3.7 \cdot 10^{-7}$	0.08	$4.6 \cdot 10^{-9}$	0.08
	$2.2 \cdot 10^{-7}$	0.30	$8.8 \cdot 10^{-8}$	0.08	$2.2 \cdot 10^{-9}$	0.05

This work was supported by the Russian Foundation for Basic Research, grants No 04-02-17874, 07-03-00339.

Poster report

Mechanical Behavior of Ultrafine-Grained Ti-6Al-7Nb Processed Using Severe Plastic Deformation

Veronica V. Nurgaleeva [a,1] , Irina P. Semenova [a,2]

[a] Ufa State Aviation Technical University, Institute of Physics of Advanced Materials

12 K. Marx St., Ufa 450000 Russia

[1] Vnurik@mail.ru, [2] Semenova-ip@mail.ru

The Ti-6Al-7Nb alloy is widely used in medicine thanks to its high specific strength, corrosion resistance and biocompatibility [1]. Usually, superplastic material flow in two-phase Ti alloys is observed in (α+β) region at the temperatures above 850^{o}C and strain rates $\dot{\varepsilon}$ = 10^{-4} c^{-1}…10^{-3} s^{-1}. At the same time, it is very important to decrease processing temperature and increase the superplastic deformation rate to facilitate forming of various articles and devices. It is well-known that one of the most efficient techniques enhancing superplastic properties of alloys is the formation of ultrafine-grained (UFG) structure by severe plastic deformation (SPD) methods [2, 3]. This paper shows that severe plastic deformation by equal channel angular pressing (ECAP) combined with further extrusion results in the formation of UFG structure with α-grains of about 200 nm in size. The alloy thus processed has much higher strength at room temperature (1400 MPa) as compared to the initial annealed alloy (950 MPa).

The mechanical behavior of UFG Ti-6Al-7Nb samples was studied at tension within the temperature range 600°…700^{o}C and strain rates of $5 \cdot 10^{-5}$…10^{-2} s^{-1}. The UFG alloy is shown to have high relative elongation and increased strain rate sensitivity to flow stress (m) at rather low temperatures. It was found that at T=600 °C and $\dot{\varepsilon}$ = 10^{-4} s^{-1} already the elongation of samples achieved 125 % with m=0.25. The maximum relative elongation (300 and 500%) with m=0.45 and 0.75 was observed within the mentioned temperature range at tension with strain rate $\dot{\varepsilon}$ = 10^{-4} s^{-1} at 650° and 700°C, correspondingly.

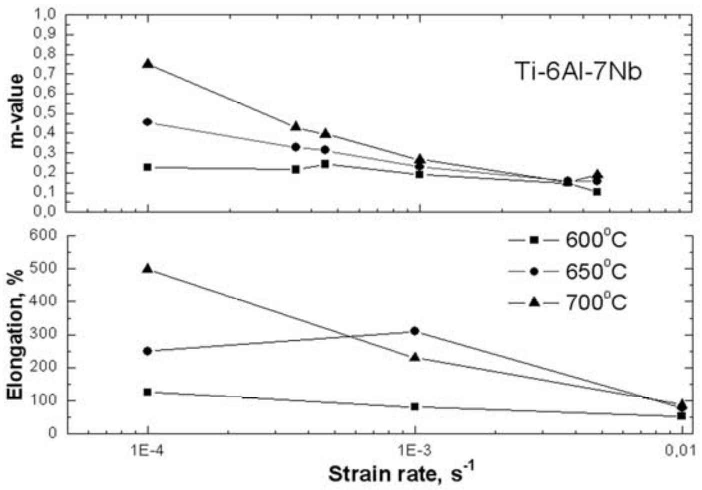


Figure 1. Dependence of relative elongation and strain rate sensitivity coefficient m on strain temperature and rate for UFG Ti-6Al-7Nb

[1] Materials properties handbook: titanium alloys /Eds. R. Boyer, G. Welsch, E.W. Collings. ASM International, (1998) p. 483

[2] O.A. Kaibyshev, Superplasticity of alloys, intermetallides, and ceramics. SpringerVerlag, (1992) 316 p

[3] R.Z. Valiev, R.K. Islamgaliev, I.V. Alexandrov, Bulk nanostructured materials from severe plastic deformation, Progr. Mater. Sci., 45 (2000) 103

Poster report

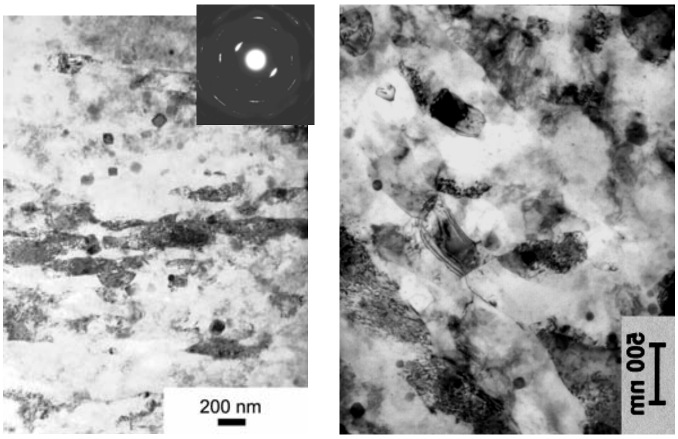
Structure and Mechanical Properties of the Al-Mg-Si Alloy after ECAP

Gulnaz Nurislamova[a,1], Maxim Murashkin[a,2] and Rinat Islamgaliev[a,3]

[a] Institute of Physics of Advanced Materials, Ufa State Aviation Technical University, 12 K. Marx St., Ufa 450000, Russia

[1] gulnaz_@mail.rb.ru, [2] maxmur@mail.rb.ru, [3] saturn@mail.rb.ru

It is known that introduction of ultrafine-grained structure in Al alloys using the procedure of severe plastic deformation (SPD) results in significant growth of their strength characteristics [1-3] caused by structure refinement and precipitation of dispersion particles. The influence of microstructure features on mechanical properties of the heat treatable Al 6061 alloy subjected to SPD processing by equal channel angular pressing (ECAP) at various regimes was studied in the present work. In the first case (regime 1) ECAP was conducted with the application of back pressure and the number of passes equal to 1. At that back pressure allowed to implement ECAP at the temperature of 50°C, which is considerably lower than the aging temperature of the given alloy. In the second case (regime 2) ECAP was conducted at the temperature of 110°C with 4 passes. Investigations of the Al alloy microstructure processed according to regime 1 educed the formation of fragmented structure with mean size of fragments equal to 0.46 μm and predominantly low-angle misorientation of fragment boundaries (Fig. 1a). Processing by regime 2 leads to the formation of ultrafine-grained (UFG) structure with mean grain size of 0.5 μm and high-angle misorientation of grain boundaries (Fig. 1b).



a b

Figure. 1: Bright field images of the Al 6061 alloy microstructure after ECAP: (a) at 50℃ with back pressure, 1 pass, (b) at 110℃, 4 passes

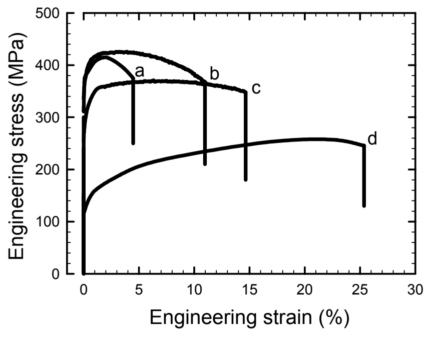


Figure 2. Engineering stress – strain curves for the Al 6061 alloy after ECAP (a) at 50°C, with back pressure and 1 pass, (b) at 110°C, 4 passes, (c) conventional T6 heat treatment and (d) solution treatment and quenching

Investigation of mechanical properties has shown that ECAP by regimes 1 and 2 results in considerable enhancement of strength properties of the Al 6061 alloy (Table 1), especially yield stress (~ 390 MPa).

Table 1. Mechanical properties of the Al 6061 alloy at ambient temperature

State	Hv, MPa	$\sigma_{0.2}$, MPa	σ_B, MPa	δ, %
ST+WQ*	750±8	150±7	275±10	23.0±1.0
T6**	1175±12	275±10	365±15	14.0±1.0
WQ + ECAP with BP at 50°C, 1 pass	1270±15	390±10	420±15	4.3±0.2
WQ + ECAP at 110°C, 4 passes	1430±15	385±10	435±15	11.0±0.6
* - alloy was solution treated 2 hours at 530°C and then water quenched in ice brine; ** - alloy was subjected to the conventional T6 aging treatment (170°C, during 12 hours).				

Analyzing the contribution of the size of UFG grains/ fragments to the material hardening according to Hall-Petch relation ($\sigma_y = \sigma_o + kd^{-1/2}$; where σ_y – yield stress, σ_o and k – constants and d – mean grain size), it was shown that for the size of grain equal to 460 nm (regime 1), σ_o = 134 MPa and k = 157 MPa $\mu m^{1/2}$ according to [4] the estimated yield stress value amounts to 365 MPa, and for the size of grain of 0.5 μm (regime 2) the estimated yield stress value amounts to 356 MPa are close to each other. Assuming that precipitation of hardening particles does not occur in case of ECAP conducted by regime 1 at the temperature of 50°C, then observed additional contribution of ~ 20 MPa to the yield stress value must be conditioned by the presence of high dislocation density in the structure. Meanwhile application of ECAP by regime 2 at higher temperature (110°C) the formation of UFG structure is attended by precipitation of dispersion particles [5]. Therefore, additional contribution of ~ 34 MPa to the yield stress value is predetermined in the given case by the precipitation of hardening phase particles as well as by the presence of enhanced dislocation density in the structure. Therefore, elevation of ECAP temperature and simultaneous increase in the number of passes (up to 4) allows to achieve higher level of the material's strength and ductility 2.6 higher due to the formation of ultrafine-grained structure and additional precipitation of dispersion particles.

[1] R.Z. Valiev, T.G. Langdon, Prog. in Mater. Sci., 51 (2006) 881

[2] S. Ferrasse, V.M. Segal, K.T. Hartwig, R.E. Goforth, J. Mater. Res., 5 (1997) 1253

[3] W.J. Kim, J.K. Kim, T.Y. Park, S.I. Hong, D.I. Kim, Y.S. Kim, J.D. Lee, Metallurgical and Material Transaction A, 33A (2002) 3155

[4] J.K. Kim, H.K. Kim, J.W. Park, W.J. Kim, Scripta Mater., 53 (2005) 1207

[5] G. Nurislamova, X. Sauvage, M. Murashkin, R. Valiev, Ultrafine Grained Materials IV. Edited by Y.T. Zhu, T.G. Langdon, Z. Horita, M.J. Zehetbauer, S.L. Semiatin, T.C. Lowe. TMS (The Minerals, Metals & Materials Society) (2006) 41

Poster report

Mechanical Properties and Microstructure of 5483 Al Alloy Processed by ECAP

Zbigniew Pakiela[a,1], Pawel Nowakowski[a,2], Lech Olejnik[b,3] and Jaroslaw Mizera[a,4]

[a] Faculty of Materials Science Engineering, Warsaw University of Technology, Woloska 141, 02-507 Warsaw, Poland

[b] Faculty of Production Engineering, Warsaw University of Technology, Narbutta 85, 02-524 Warsaw, Poland

[1] zpakiela@inmat.pw.edu.pl, [2] salias@interia.pl , [3] lolejnik@wip.pw.edu.pl
[4] jmizera@inmat.pw.edu.pl

It is well known that plastic deformation during equal channel angular pressing (ECAP) in not perfectly homogeneous. There were published many experimental and theoretical evidences of this fact obtained by various methods such as microstructure observations, micro-hardness measurements and computer modeling.

The aim of presented paper was the investigation of the homogeneity of mechanical properties and microstructure of the Al alloy processed by ECAP. Rectangular samples of 5483 Al alloy processed by ECAP in an L-shaped, 90^{o} channel at 180 ^{o}C using route Bc were used for investigations. For the aim of the investigations there were performed standard tests, such as micro-hardness measurements, TEM observations and tensile tests of non-standard micro-specimens cut-out from various parts of the samples processed by ECAP. The investigation was carried out for samples subjected to 1, 4 and 8 passes of ECAP.

It was found that tensile strength, yield strength and elongation to rupture strongly depend on the location within the ECAP sample. These properties changes both along the rod-shaped samples and across their thickness. It was also found that non-homogeneity of mechanical properties increases with the number of ECAP passes. The highest strength was found in the middle part of the ECAP samples. These results were proved by micro-hardness measurements and by TEM observations.

Poster report

Investigation of Corrosion Properties St3 in Coarse-Grained and Ultra Fine-Grained Conditions

Nailya A. Amirhanova[a,1] and Albina F. Razyapova[b,1]

[a] Ufa State Aviation Technical University, 12 K. Marx St., 450000, Ufa Russia

[b] Baskir State University, Frunze St. 19 450000 Ufa Russia

[1]albina_razyapova@mail.ru

It is known, St3 not containing alloying ingredients is corrosion active steel. It is interesting to consider in comparison corrosion properties of St3 in coarse-grained (CG) and ultra fine-grained (UFG) conditions. St3 with CG structure has grains in the size of 50-80 micron, and steel after exactly channel deformation has major extent of boundaries of grains in the size of 0.3-0.5 micron.

Change of potential without a current for St3 in CG and UFG condition in 3% NaCl, 5% $NaNO_3$, 0,1 N HCl water solutions was studied in comparison. Comparison of curves of potential without a current for St3 in CG and UFG condition in 3% NaCl water solution testifies to at immersing of specimens in solution, sharp shear of potential without a current in region of more negative values is observed. Steadied value of potential without a current for St3 with UFG structure has more electronegative in comparison with specimens with CG structure (-0.4 and -0.35 respectively).

For St3 in a CG condition after the protracted immersion in 3% NaCl water solution are observed pittings and rather broad areas of a corrosive attack are observed, and microstructure of steel in UFG condition is characterized local etching, which almost uniformly propagated on a surface.

The potential without a current in 5% $NaNO_3$ water solution changes as well as in 3 % NaCl water solution, i.e. steady-state value for UFG structure has more negative value, than for steel with CG structure (-0.275 and-0.15 respectively).

Not looking at that NO_3^--ion renders passivating action, St3 with UFG structure more corrosion active, than with CG structure.

Corrosion rate St3 in CG and UFG conditions were determined by gravimetric method It is established, corrosion rate for St3 with UFG structure in all electrolytes is higher, than for specimens with CG structure.

Thus**,** investigation of corrosion properties of St3 in CG and UFG conditions in different corrosive mediums has shown, that steel with UFG structure having smaller value of a grain, a great many of defects and extent of boundaries, more corrosion active.

Poster report

Submicrocristalline Structure Formation in Mg-Al-Ca Alloy during SPD

Lazar L. Rokhlin[a], Sergey V. Dobatkin[a,b,1], Yury Estrin[c,2], Mikhail V. Popov[b, c], Tatiana V. Dobatkina[a], Vladimir N. Timofeev[a], Nadezhda I. Nikitina[a] and Irina E. Tarytina[a]

[a] A.A. Baikov Institute of Metallurgy and Materials Science of RAS,
49 Leninskii Pr., Moscow 119991, Russia

[b] Moscow State Institute of Steel and Alloys (Technological University),
4 Leninskii Pr., Moscow 119049, Russia

[c] Clausthal University of Technology, Agricolastrasse 6, D-38678, Clausthal-Zellerfeld, Germany

[1] dobatkin@ultra.imet.ac.ru, [2] juri.estrin@tu-clausthal.de

Magnesium alloys are of special interest for the structure strengthening since they the lightest structural metallic materials. The aim of the work was to study the possibility of the formation of nano- and submicrocrystalline structures in the Mg-0.62 % Al-0.57 % Ca alloy upon severe plastic deformation (SPD).

SPD was performed by high pressure torsion (HPT) at T=20□C of the samples of 10 mm in diameter and 0.6 mm in height to ε ~ 6 and by equal channel angular pressing (ECAP) at T=200-300□C to ε ~ 4-6 of the samples of 10x10x40 mm in size.

HPT at 20□C causes a substantial strengthening of the Mg-0.62% Al-0.57% Ca alloy. This can be explained by the formation of submicrocrystalline structure with a grain size of 100-200 nm.

The effect of SPD on the aging kinetics of the Mg-0.62% Al-0.57% Ca alloy taken in the initial as-cast state and after quenching was studied by the measurements of specific electrical resistance and microhardness as a function of aging time at 175°C. The possibility of aging after HPT at the expense of the Al_2Ca phase precipitation has been first shown in the Mg-Al-Ca alloy.

The ECA pressing was performed for the initially annealed, quenched, and preliminarily extruded states. The tests for mechanical properties at temperatures of 20 and 160°C showed the possibility of simultaneous increase in the strength and plasticity of the submicrocrystalline Mg-0.62% Al-0.57% Ca alloy.

The work was supported by the Federal Program of Russian Ministry of Education and Science (contract no. 02.513.11.3141) and the Program of Presidium of Russian Academy of Science.

Poster report

Structure and Properties of Mg-Sm Alloys after SPD

Lazar L. Rokhlin[a], Sergey V. Dobatkin[a,b,1], Yury Estrin[c,2] Rimma Lapovok[d,3], Mikhail V. Popov[b, c], Tatiana Dobatkina[a], Vladimir N. Serebryany[a], Vladimir N. Timofeev[a], Nadezhda I. Nikitina[a] and Irina Tarytina[a]

[a] A.A. Baikov Institute of Metallurgy and Materials Science of RAS, 49 Leninskii Pr., Moscow 119991, Russia

[b] Moscow State Institute of Steel and Alloys (Technological University), 4 Leninskii Pp., Moscow 119049, Russia

[c] Clausthal University of Technology, Agricolastrasse 6, D-38678, Clausthal-Zellerfeld, Germany

[d] Monash University, Victoria 3800 Clayton, Australia

[1] dobatkin@ultra.imet.ac.ru, [2] juri.estrin@tu-clausthal.de, [3] rimma.lapovok@spme.monash.edu.au

The behavior of Mg-Sm alloys, which exhibit high effect of age hardening and high strength at elevated temperatures, was studied upon severe plastic deformation (SPD).

The alloys containing 2.8-5.5 wt. % Sm (the maximum solubility of Sm in solid magnesium is 5.8 wt %) have been taken for the study. High pressure torsion (HPT) was performed for the samples of 10 mm in diameter and 0.6 mm in the initial thickness under a pressure of 4 GPa at room temperature and at 200°C to $\varepsilon \approx 6$ (5 revolutions). Equal channel angular pressing (ECAP) was performed for the samples of square (10x10mm) and round (10 mm in diameter) cross sections at T=200-300°C.

Three following routes can be used for the realization of the high-strength state in the combination with high thermal stability of the submicrocrystalline Mg-Sm alloys:

(1) Preliminary aging at 200°C before deformation + SPD at 20°C + subsequent aging with further decomposition of the solid solution in the submicrocrystalline matrix.

(2) SPD of the quenched state at 200°C with the occurrence of partial strain aging + after-deformation aging.

(3) SPD of the quenched state at 20°C for the maximum grain refinement + after-deformation aging.

The mechanical properties of Mg-Sm alloys determined after ECAP by the tensile tests at temperatures of 20 and 250°C are discussed.

The work was supported by the Federal Program of Russian Ministry of Education and Science (contract no. 02.513.11.3141) and the Program of Presidium of Russian Academy of Science.

Poster report

Study of the Annealing Effect on Microstructure and Mechanical Properties of Ultrafine-Grained Ti Rods Processed by Severe Plastic Deformation

Gulnaz Kh. Salimgareeva[a,1], Michael Zehetbauer[b,2], H.P. Karnthaler[b,2], Bernhard Mingler[b,4] and Irina P. Semenova[a,5]

[a] Ufa State Aviation Technical University, 12 K. Marx Str., Ufa 450000 Russia

[b] Physics of Nanostructured Materials, Faculty of Physics, University of Vienna, Boltzmanngasse 5, AT1090 Vienna, Austria

[1] sadikova_gh@list.ru, [2] michael.zehetbauer@univie.ac.at , [3] hans-peter.karnthaler@univie.ac.at , [4] bernhard.mingler@univie.ac.at, [5] Semenova-ip@mail.ru

Recently, it has been proved that grain refinement in metals and alloys leading to the ultrafine-grained (UFG) structures allows to considerably enhance the physical and mechanical properties including strength, fatigue resistance and superplasticity [1, 2]. However, ductility of many UFG materials is often lower than those of their coarse-grained counterparts, which is connected with the physical nature of ultrafine grains. Some ingenious approaches are to be developed in order to achieve both high strength and ductility in UFG Ti materials.

Some recent investigations have shown that UFG Ti materials have complex microstructures and their properties depend on the type of severe plastic deformation (SPD), the thermomechanical treatment, and the annealing procedure. This work aims at the study of the effect of temperature (between 300°C - 550°C) and duration of final annealing, on the microstructure and the mechanical properties of UFG CP-Ti Grade 4 rods. These rods were processed by combination of equal channel angular pressing (ECAP) and further thermomechanical treatments. The microstructure evolution induced by the increase in annealing temperature and duration was studied by transmission electronic microscopy and differential scanning calorimetry. The investigations showed that the processes recovery, recrystallization and grain growth taking place during annealing at 350 to 500°C were accompanied by the precipitation of secondary phase particles. Another interesting result was that annealing of UFG Ti Grade 4 at 350°C resulted in an additional strength increase with simultaneous enhancement of ductility.

[1] R.Z. Valiev, Nature Mater., 3 (2004) 511

[2] R. Z.Valiev, I.V. Alexandrov, Y.T. Zhu, T.C. Lowe, J.Mater.Res., 17 (2002) 5

Poster report

Structural Changes under Light Irradiation in the Nanostructural Carbon Nitride Films

Rostyslav Shalayev[a,1], Victor Varyukhin[a,2], Anatoliy Prudnikov[a], Alexander Yakovec[a] and Alexander Ulyanov[a]

[a] Donetsk Phys.&Tech. Institute of NASU, 72 R.Luxembourg St., Donetsk 83114, Ukraine

[1] sharos@mail.ru, [2] var@hpress.fti.ac.donetsk.ua

Carbon nanostructures, doped by boron or nitrogen, show the exciting electronic [1] and structural [2] properties. As it is known, when producing the carbon nitrides there are some problems caused by peculiarities of C-N bond formation. High activation barrier [3] for the nitrogen insertion into the carbon film structure is hardly to be overcome by the CVD and PVD method for the films deposition. Also, nitrogen atoms mainly enter into films in the form of sp^2- and sp-bonds [4]. It results an enlarging the graphite clusters, forms soft and loose condensates with spatial structure discontinuity. Except it, at substrate temperature higher than 500-600° C the thermal gasification of grown materials with the cyanogens (C_2N_2) formation was observed [5]. Above factors forced to find alternative ways for activation of gas phase and growing surface. Electromagnetic radiation of grown film surface and gas phase nearby the surface strongly affects both the process of growth and properties of diamondlike carbon (DLC) films. Low power visible range irradiation during film growth improves quality of DLC films because diamond is transparent in above band of radiation, but graphite and amorphous carbon absorb a radiation, stimulating the desorption such non-diamond carbon phase from the surface. We present here the successful growth of CN_x nanotubulated films on quarts glass at low temperature by d.c. magnetron sputtering. Effect of low power ultra violet (UV) irradiation on the structure and properties of the films during their growth is also studied.

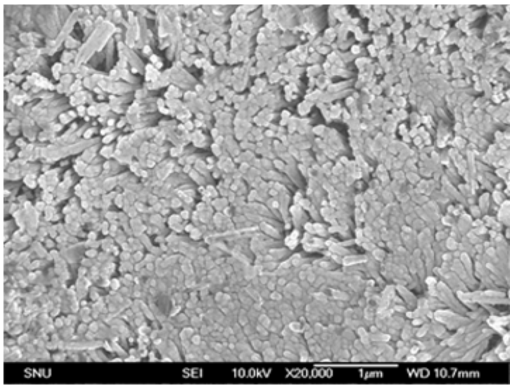


Figure 1. SEM-image of the UV-irradiated film surface

CN_x films were grown by magnetron sputtering of graphite target in pure nitrogen atmosphere and represent densely packed nanocolumns with diameter ~60-70 nm. The columns are packed in blocks, containing about 20-30 columns. The morphology of the films, subjected to UV radiation during growth, is different from that of non-radiated films: these films are denser, and almost does not show the block structure

(Fig.1). Nitrogen and carbon contents, defined by EPMA method, show an increase of nitrogen in irradiated films. This also confirmed means of the IR absorption spectra. IR absorption spectra of films obtained under UV-radiation show essential increasing of integral intensity of lines, corresponding to N-containing bonds and decreasing of C-H (2800-3000 cm^{-1} line intensity as compare with non-irradiated films. It shows that UV radiation is effective tool to increase an incorporation of nitrogen into the film structure and to break the C-H bonds, thus removing chemically bonded hydrogen from the film structure.

[1] R. Kurt , J.-M. Bonard, A. Karimi, Carbon, 39 (2001) 1723

[2] X. D. Bai, D. Zhong, G. Y. Zhang, X. C. Ma, Appl. Phys. Lett., 79 (2001) 1552

[3] T. R. Lu, L. C. Chen, K. H. Chen et al., Thin Solid Films, 332 (1998) 74

[4] S.E. Rodil, A.C. Ferrari, J. Robertson, and W.I.Milne, J. Appl. Phys., 89 (2001) 5425

[5] O. Durand-Drouhin, M. Lejeune, M. Clin at al., Solid State Commun, 118 (2001) 179