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„The EU Framework Programmes - Our Future“

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Sborník abstraktů

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Microstructure and properties of ultrafine grained and nanocrystalline metals and alloys

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Abstract

Our research interest is focused on the basic properties of interfaces and their interaction with other lattice defects leading to complex defect reactions that have a large impact on materials properties and performance. In our laboratory, materials are synthesized by different methods and the main characterization methods are based on scanning and transmission electron microscopy, calorimetry and thermal analysis, mechanical testing and indentation, low-temperature transport and optical properties and radiotracer diffusion. The combination of a large range of complementing characterization tools allows for an in-depth analysis of microstructure-property relationships.

Keywords

Nanocrystalline; nanostructured; ultrafine grained; microstructure; mechanical properties; thermodynamics; diffusion kinetics.

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Presentation of the metallurgical preparation facilities at ICMPE and recent contributions

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Abstract

The Materials Preparation Facilities at ICMPE aims to organize and realize the preparation and manufacturing of metallic and ceramic samples needed by the researchers of our Institute. This regroups:

- the synthesis and preparation of metallic alloys and ceramics,

- the microstructure definition,

- the forming of samples.

I will present the set of experimental techniques that allow us to cast metals with cooling rates up to 1 000 000 K/s, prepare oriented microstructures, or sinter bulk products by metallurgy powder routes, especially spark plasma sintering.

Some examples of recent research on nano scaled materials will also be introduced.

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Formation of nano-architectures using powder metallurgy

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Abstract

Our work on UFG metals is focused today on the powder processing using the spark plasma sintering technique. The SPS has proved to form parts with absence of grain growth and potentially interesting mechanical properties. The most interesting perspectives are seemingly on the possibility to form controlled architectures and nano composites with improved and relevant properties. I shall present results on the fabrication of nanostructured copper as well as metallic glass – aluminum composites. The later were also severely deformed (collaboration with X. Sauvage, CNRS Rouen France and R. Pippan, Acad. Sc. Loeben, Austria) leading to interesting nano-complex structure. Mechanical properties analysis has been initiated on these materials.

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Structure and properties of ball milled and consolidated metal-ceramic and metal amorphous composites

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Abstract

Several types of metal matrix composites were prepared by ball milling and subsequent hot pressing in vacuum. The matrix was chosen either aluminum alloy for structural applications or silver for contact materials. As the strengthening phase were used either Al_2O_3 or ZrO_2 oxides or metallic amorphous powders prepared by spray forming. 40 hours ball milled powders of 7475 alloy with additions of 10= 20% of ZrO_2 allowed obtaining powders of uniform distribution of ceramic particles and nanometric size (below 50 nm) of the grains of the aluminum solid solution. The microhardness of milled powders was in the range of 230-270 HV and the Young modulus near 140 GPa. The low porosity composites were obtained after hot pressing in vacuum under pressure of 600 MPa and temperature 380^{o}C. Insignificant grain growth of aluminum solid solution was observed to be slightly above 100 nm. ZrO_2 and Zr particles reacted with magnesium from the aluminum solid solution forming the transition MgO rich layer around the ZrO_2 ceramic and Zr particles.The compression strength of composites with nano ZrO_2 particles additions was near 990 MPa, while those of larger particle additions was only slightly lower. All composites showed also a moderate plastic deformation in compression mode near 3 %.

Another type of composites were prepared by hot pressing in vacuum of an aluminium powder with 20 and 40 wt. % addition of the amorphous Cu43Zr43Ag7Al7 (numbers indicate at. %) alloy obtained using gas atomisation method. The uniaxial hot pressing in vacuum allowed to obtain composites of hardness from 43 HV to 53 HV for both compositions of the amorphous phase and the compression strength of 150 MPa for 20 % of amorphous phase and 250 MPa for the higher content. The modest hardening effect was caused by crack initiation at the Al/amorphous interfaces. Application of the nanocrystalline aluminum powders obtained by high energy ball milling for the matrix of composites allowed to obtain nanocrystalline aluminum matrix composites strengthened with the amorphous powders, which compression strength near 550 MPa for the composite containing 40% of the amorphous phase.

The third investigated kind of composites were silver base composites strengthened with 1 or 2% of graphene addition due to a high mechanical properties and electrical conductivity of graphene. The commercial graphene contained up to 4-9 layers of 0001 carbon hexagonal layers. The composites were hot pressed at 520^{o}C and they contained rather regular distribution of spherical as results of HR TEM studies nanographite phase. The addition of graphene caused hardness increase of composites with 2 % grapheme up to 74 HV what is about 50% increase in comparison

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to solid Ag.

Selected metal forming methods for obtaining ultrafine-grained microstructure

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Abstract

The paper presents opportunities to obtain ultrafine-grained microstructure in metallic materials by cold forming with controlled strain path. A number of unique laboratory devices have been developed and launched at the Faculty of Materials Science and Metallurgy in the Silesian University of Technology for studying unconventional forming methods of such kind. The devices permit to perform various loading cases: compression with oscillatory torsion, forging aided by shear stress and rolling with transverse motion of rolls. The results of experiments and numerical simulations obtained so far have proved that repetitive changing of the strain path provided by cyclic change of loading scheme leads to significant grain refinement and controlled improvement of functional properties of a product. Moreover, the flow stress of materials deformed in these conditions is lower than in conventional processes. As a result, it enables for reduction of the force required to perform cold forming operations without preheating a workpiece. On a basis of the obtained results and experience gained during the experiments, perspectives for continuation of the studies and possible industrial applications areas are discussed in conclusion.

Keywords

Ultrafine-grained microstructure; controlled strain path; compression with oscillatory torsion; forging aided by shear stress; rolling with transverse motion of rolls.

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UFG shape memory and magnetic shape memory materials

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Abstract

The paper presents recent results concerning the magneto-structural investigations of magnetic shape memory materials based on the Heusler Ni_2MnX structure. Ternary Ni-Mn-Sn and quaternary Ni-Mn-Sn-Al and Ni-Mn-Fe-Sn melt spun ribbons with ultra fine grain are presented. In ternary $Ni_{50-x}Mn_{37+x}Sn_{12.5}$ alloys the effect of Ni/Mn concentration ratio on microstructure and martensitic transformation in the composition range between $0 \leq x \leq 6$ has been investigated. In the quaternary $Ni_{48}Mn_{39.5}Sn_{12.5-x}Al_x$ (x=0, 1, 2, 3) Heusler alloys ribbons the room temperature magneto-structural transitions were examined as well as effect of Mn substitution for Fe on magnetic and martensitic transformations in $Ni_{46}Mn_{41.5-x}Fe_xSn_{12.5}$ ribbons. The several techniques and apparatus like X-Ray diffraction, transmission and scanning electron microscopy (TEM, SEM), differential scanning calorimeter (DSC) and vibrating sample magnetometer (VSM) were applied for this investigations.

Keywords

Magneto-caloric effect; Heusler alloys; rapid solidification; ultra fine grain materials; martensitic transformation; magnetic transformation; microstructure.

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INVESTMENTS IN EDUCATION DEVELOPMENT

Application of SPD processes for manufacturing the applicable materials with nanometric structure on the base of magnesium and aluminium

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Abstract

Progress of civilization of world community effects intensive searching of new metallic materials characterized by low weight and good mechanical and plastic properties. Lately scientific research is focused on magnesium alloys. Unfortunately, the magnesium is characterized by very low corrosion resistance and it is necessary to search a various solutions which help to solve this problem in practical applications.

The research concerning various SPD processes for obtaining materials with nanometric structure on the basis of magnesium and aluminium is proposed. In the project the rule is that for investigation will be chosen only processes which results the application in industry. The main goals of the project are production of multilayer Mg-Al composite with aluminium outer layers and magnesium inner layers and also bimetal rod with magnesium sleeve and aluminium core. The composite of Mg-Al will be obtained by using modified ARB process where the flat rolls are replaced by box pass which eliminates the spread of the band. Moreover, an asymmetric rolling process will be used. The bimetal Mg-Al rod will be produced by ECAP process. It is assumed that during the ECAP process in optimal conditions the joining of the layers and refinement of the structure is possible. The third direction of the research is application of the multi-axial forging process to refinement structure of Mg-Al alloy. Such produced material will be the base material to compare the mechanical properties with properties of materials obtained in ARB and ECAP processes. The expected results of the project is production of new functional materials which will be characterized by low weight and relatively high strength and plasticity, good corrosion resistance and also can be produced in industry processes.

Keywords

SPD ECAP ARB processes; Mg-Al bimetal; Mg-Al alloys; multi-axial forging.

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Development of Advanced Techniques for Incremental Bulk AlMg3 Nanostructure Alloy Forming

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Abstract

The most important parameters of Equal Channel Angular Pressing (ECAP) as contact friction and tool design are discussed. Experimental material behaviour of AlMg3 plays very important role during severe plastic deformation and this experimental material was considered as an ideal plastic body. The rotary forging (RF) was used as following operation after ECAP. RF is an advanced precision and relatively new technology that combine forging (upsetting) and axial rolling. RF is incremental deformation process uses only small fraction of the force required for conventional forging. This process was applied on nanostructured AlMg3 obtained by ECAP process. The measure of crystal morphologies by using the scanning electron microscope (SEM) with electron backscattered diffraction (EBSD) after ECAP and RF is discussed.

Keywords

Equal channel angular pressing; incremental plastic deformation; nanostructure; alloy AlMg3.

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Vacuum surface treatment of heat treated cast light alloys

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Abstract

In this paper there are presented investigation results concerning surface treatment of Mg-Al-Zn, Al-Si-Cu magnesium and aluminium alloys. In the present work, the emphasis is set on current practices and future trends for nanocomposite thin films and coatings deposited by physical vapour deposition (PVD). The presented results reveals the characteristics of surface treatment as well as the structure and properties of magnesium and aluminium cast alloys, used as constructional materials. The surface treatment of the these alloys was carried out with the use of physical deposition methods, especially the CAE PVD. The results confirms, that the performed standard heat treatment, consisting of solution heat treatment with cooling in water, as well aging with cooling in air, causes strengthening of the MCMgAl9Zn1, MCMgAl6Zn1, AlSi9Cu and AlSI9Cu4 alloy according to the precipitation strengthening mechanism, induced by inhibition of dislocation movement due to the influence of strain fields of the homogeny distributed phase Mg17Al12 as well as Al2Cu precipitates. The combination of properly chosen heat treatment with the possibilities of structure- and phase composition the PVD vacuum method ensures an additive increase of mechanical and functional properties by significant grain refinement as well as a gradient micro-composite multilayer coating deposited on the material surface. In conventional bulk materials, refining grain size is one of the possibilities for hardness increase. The same is true for nanocomposite films or coatings. It was confirmed in this paper to obtain coating materials with high hardness, higher than the hardness of traditional polycrystalline coatings.

Keywords

Manufacturing and processing; PVD coatings; Light alloys, Heat treatment; Structure; Surface.

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Prior structure modification on grain refinement and mechanical properties of medium carbon steel

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Abstract

The work presents the results on grains refinement of steel containing 0.45 wt pct. carbon resulted from severe plastic deformation (SPD). Different steel structures resulting from prior solutioning and/or thermomechanical (TM) treatment were prepared for deformation experimental. A coarse grain ferrite-pearlite structure was achieved applying solutioning. By application of TM control forging process, performing multistep open die forging, the refined ferrite-pearlite mixture was resulted. Final steel structure refinement, having different initial structure, was then accomplished applying warm Equal Channel Angular Pressing (ECAP) at 400°C. Employment of this processing route resulted in extensive deformation of ferrite grains and cementite lamellae fragmentation. Applying the highest shear stress (ε_{ef} - 4) the mixture of subgrains and ultrafine grains was found in former equiaxed ferrite grains. On the other side, in pearlite grains, modification of cementite lamellae due to shearing, bending, twisting and breaking was found efficient in pearlite lamellae refining. The coarse cementite lamellae spheroidization was more efficient when prior TM treatment modified steel microstructure. The tensile deformation records then confirmed strength increase and diversity in strain hardening behaviour.

Keywords

Medium carbon steel; solutioning; TM treatment; SPD; ECAP; microstructure; properties.

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INVESTMENTS IN EDUCATION DEVELOPMENT

Possibilities of Utilization of Light Metals in the SPD Process

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Abstract

Currently, technological progress in many modern industries requires in implementation of new types of technical materials and related development of new manufacturing technologies that bring both enhancement of service properties of final products, as well as their wider implementation into engineering practice, including the associated energy savings. One possibility is also a constant increasing of consumption of light metals. Sustainable development of human society is subject to a maximum economy of non-renewable sources of energy and raw materials, especially metallic ones. One of the ways for achieving this goal, in addition to recycling waste alloys based on aluminium, copper and magnesium, is systematic reduction of their consumption by increasing their quality and service life of utility objects and structures made from them. Already for many years, this happens in metallurgical production for example by alloying or by heat treatment. One of the ways to the more effective use of metallic materials is their processing by forming. At present in this the area the use of the process of multiple severe plastic deformation (SPD process), leading to a refinement of the structure (materials with UFG structure) and thus to achievement of higher level of their utility value, is expanding.

Keywords

SPD process; light metals; grain refinement; mechanical properties; structure.

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Non-Traditional Use of Torsion Plastometer in Physical Simulation of Deformation Processes

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Abstract

The present paper provides a picture of metallographic and plastometric research in the border areas of steel production and forming. The focus of the paper is simulation conducted in SETARAM plastometer. The SETARAM plastometer used in the experiments has been modified recently. The changes concerned predominantly its temperature measurement and control devices. The lower limit of its operating temperatures was reduced to approximately 400 °C. The purpose of the most recent upgrade was to allow investigation in the region of steel brittleness related to loading in their freezing range. It will be possible to explore the behaviour of steels under the conditions of continuous casting processes, solidification in crystallizers and deformation during solidification. Microstructures of various types of steels are presented upon small continuous deformation applied at high temperature, which lead to partial melting and resolidification of test bars.

Various types of sheet rolling simulations with reduced finish temperatures conducted in the plastometer are described. Approaches to evaluating continuous torsion tests to fracture in the field of basic research into materials plasticity are presented as well. In terms of interrupted tests, the importance of the anisotropic interrupted test as a source of information for research is touched upon. In particular, demonstration is given of the potential for finding transformation temperatures governed by deformation in the 1.0583 steel grade. A physical simulation procedure involving strain-induced ferritic transformation has been developed on the basis of results of tests. Mechanical properties were measured on specimens processed in the simulation. Microstructures resulting from the thermomechanical simulation are discussed.

Keywords

Torsion test; large deformations; microstructure; plasticity; steels.

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Automotive industry requirements related to new materials application

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Abstract

Development automotive industry and global depression doing of new requirements on cost saving in the time.

In terms of development companies economies and prediction of loss on the global market is necessary of search for alternative market on the basic economical prediction.

Firstly for growth of company and positive economical develop is implementation of innovation production programs and alternatives material to serial production. Necessary is use of currently capacity of industrial production.

Suppliers to automotive industry search cost saving in products portfolio and search new opportunities of companies marketing. The supplier's primary generated of cost saving in investment.

Obviously these aspects have of implementation of new materials to serial productions, which it has in the reason of high investment in modernization of production process and increasing of product quality.

Strategically is necessary be on the look for new industries for exercise of nanomaterials, that are not dependent of economies stagnation.

Keywords

Economies stagnation; Development; Nanomaterials; Automotive industry; Serial production.

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EU R&D projects - experience with the proposal evaluation

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Abstract

The presentation concerns about the evaluation of the international project proposals. The experience with procedures of evaluation procedures of the European Community R&D programmes is performed within the programmes „Research Fund for Coal and Steel" and FP7.

The particular steps of proposal evaluation are discussed in light of pilot and demonstration projects, their evaluation (justification of marking, resubmitted proposals, outcome of the individual evaluation, thresholds), consensus (consensus meeting, marking, outcome of the consensus meeting) and ranking.

The presentation is focused on the individual evaluation process of proposals, deals with the evaluation criteria – such as scientific and technical approach, innovative content, consistency of resources and quality of partnership, industrial interest and scientific/technical prospects, added value for the European Union and contribution to EU policies.

Knowledge of the evaluated criteria and evaluation procedures is very important. Cognition in this field may significantly increase the probability chances to obtain the financial support from the EU funds.

Keywords

EU funds; R&D projects; proposal; evaluation process; evaluation criteria.

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INVESTMENTS IN EDUCATION DEVELOPMENT

Magnesium-based Composites

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Abstract

Magnesium alloys exhibit a high specific strength. Grain refinements, precipitation, solid solution hardening are oft used in order to increase the strength of Mg alloys. An effective method is particle or fibre-reinforcement that is useful for improvement of strength of alloys at elevated temperatures. In the present study, we will present examples showing how the addition of short fibres or particles influences the mechanical properties of pure magnesium and magnesium alloys. Tensile (compression) tests were performed at room temperature and over a wide temperature range. Reinforcements and matrix Mg alloys have different mechanical, chemical and physical properties. This causes changes in properties of the composite. Reinforcements have usually coefficient of thermal expansion different from that of a matrix. The present of reinforcements with different thermal expansion coefficient may increase the dislocation density. The density of the newly created dislocations depends on the reinforcement volume fraction, the reinforcement shape and the difference in the coefficient of thermal expansion of both of the composite components. Therefore strength, plastic deformation and physical properties are influenced. The yield stress of magnesium alloys increases strongly if a small volume fraction of nanoparticles is used as reinforcement.

Keywords

Magnesium composites; mechanical properties.

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Evaluation of seasoning of strip from low-carbon steel

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Abstract

Contribution concerns evaluation of formability of strip from low-carbon steel DC04, which is mostly used in Czech Republic for production of intricate deep stampings. The properties of strip were fully evaluated by tensile tests and by cupping tests according to Erichsen. The tests were carried out 2, 4, 6, 8, 10 and 12 months after the date of steel strip production.

Nevertheless the solitary mechanical properties are not sufficient for correct choice of sheet--metal according to its formabiity, the planar anisotropy of mechanical properties, the directional and mean values of normal plastic anisotropy ratio and the strain-hardening exponents were evaluated. Acording to these criteria it is possible to determine the formability of sheet-metal for concrete shapes of stampings even to choose better the sheet-metal according to its formability.

At strip from steel DC04 owing to storage small modification of properties came about predominantly in direction to lower formability of sheet-metal.

By storage of steel the mean value of strain-hardening exponent, nm, which is crucial for stretchability, decreased about 1.8 %. According to lower nm value the speed of strain-hardening at drawing is lower, the transposition of plastic deformations from places with great initial stress (biaxial tension zone) to places with lower initial stress is slower and that is why less uniform situation of deformations on stamping arises at drawing. The decreased value of nm give evidence about the fact, that by storage the suitability of steel strip for the cases of deep drawing, where tension mechanical schemes of deformations predominate, decreased.

The exception is the mean value of plastic anisotropy ratio rm, which by storage of steel increased about 10.4 % in direction to higher formability of sheet-metal. The value of rm = 1.49, found at strip from steel DC04 stored 12 months, gives evidence about increasing the resistance of sheet-metal to thinning at deep drawing and about increasing the suitability of this steel strip for the cases of deep drawing, where pressure-tension mechanical schemes of deformations predominate.

It is concluded that stored steel strip is suitable for the cases of drawing of flat stampings, where pressure-tension, eventually combined mechanical schemes of deformations occur.

Keywords

Formability; strip; steel; tensile test; cupping test; seasoning.

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INVESTMENTS IN EDUCATION DEVELOPMENT

Influence of grain structure, texture and precipitation on properties of Aluminium heat treatable alloys after inhomogeneous plastic deformation

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Abstract

Various types of structures differing in work-hardening state, recovery, recrystallization, and grain- and subgrain orientation and dimensions are formed during plastic deformation. These structures depend on deformation temperature, intensity and inhomogeneity. When precipitation occurs in these structures, mechanical properties will be changed in dependence on the type of structure. In many cases, mechanical properties become inhomogeneous, their values differ substantially in different directions i.e., on the orientation of test piece. These effects are typical for hardenable Al alloys and are not quite understood as yet. Inhomogeneity and anisotropy of structure and properties are relatively well described in industrial applications (extrusion, forging, rolling); on the other hand, in case of a severe plastic deformation, during which a quite specific wrought structure is formed, that information completely lack for the time being. „Interaction“ between grains- and subgrains structure (size, orientation, dislocation density) and precipitation of hardening phases seems to be an interesting topic that could contribute to a better understanding of these processes and their exploitation in obtaining the structures with extraordinary properties.

Keywords

Plastic deformation; SPD; precipitation; grain structure; properties; aluminium alloys.

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