

RESEAU FRANÇAIS DE MECANOSYNTHESE

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147 Groupes de Recherche
(dont 82 à l'étranger / 33 Pays)

Bureau : E. Gaffet (Président), G. Le Caër (Secrétaire Général), A.R. Yavari (Trésorier)

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13 Nouvelles Adhésions

N. Bouad - Lab. Physico - Chimie Matière Condensée - Montpellier - France
J.P. Braganti - Lab. Chimie du Solide Minéral - CNRS - Vandoeuvre les Nancy - France
L. Chapon - Lab. Physico - Chimie Matière Condensée - Montpellier - France
M. Descamps - Lab. Dynamique & Structure des Mat. Moléculaires - CNRS/Univ. Lille - France
M.S. El-Eskandarany - Mining and Petroleum Engineering Dpt - Le Caire - Egypte
P. Goeuriot - Ecole des Mines - St Etienne - France
O. Held - Lab. Chimie du Solide Minéral - CNRS - Vandoeuvre les Nancy - France
M. Khelifati - Groupe Métallurgie Physique - CNRS / Univ. Rouen - Rouen - France
D. Larcher - Dpt of Physics - Dalhousie University - Halifax - Canada
R.M. Marin - Ayril - Lab. Physico - Chimie Matière Condensée - Montpellier - France
J. Seidel - Fritsch GmbH - Idar Obsertein - Allemagne
A. Tidu - LETAM - Univ. Metz - France
D. Zhang - Dpt Technology - Univ. Waikato - Nouvelle Zélande

Le site web du RFM est le suivant

<http://www.bls.fr/amatech>

Rubrique Pages Sciences et Techniques pour l'Ingénieur (Rubrique Sciences)

⇒ vous y trouverez les anciennes lettres du RFM (accessible par Adobe Acrobat)

les statuts du RFM ainsi que les annonces concernant les JRFM'99 et quelques éléments mis à jour régulièrement concernant les derniers résultats dans ce domaine.

Compte Rendu de la Réunion des Sociétés Savantes Françaises

(Extrait du Compte Rendu rédigé par Y. Franchot (Secrétaire Général de la SF2M) et n'engage que cette société)

Rappel : A l'initiative de Y. Farges (Ancien Président de la SF2M) est menée une réflexion depuis les Assises "Matériaux de Lyon", portant sur l'un des aspects de la (re)structuration de la recherche au travers des 32 Sociétés Savantes françaises.

La deuxième réunion a eu lieu le 5 Mai 1999. Ci dessous figure le compte - rendu de cette réunion (selon la SF2M).

Ces quelques éléments ont pour objet d'amorcer l'une des discussions des prochaines JRFM'99 qui porteront sur l'évolution du RFM.

Etaient présents(10)

AFM (J.C. Lachat Pt), ANRT Sion 8 (L. Beaunier), CEFRACOR (M. Hélie M. Marcus), GFC (M. Beauvy), GFCC (G. Faivre), GFP (J.C. Daniel R. Schirrer), SFGP (J. Decaure Pt), SFμ (M. Aucouturier), SFV (M.G. Barthes Vice Pt M. Cantarel S.G.), SF2M (G. Beck Pt J.P. Chevalier Y. Farge ancien Pt Y. Franchot S.G.)

Etaient excusés ou absentes(20)

AAAF AMAC ATF ATTT CEM COFREND DYMAT GAMAC GFEC MECAMAT RFM SCI SFEN SFC SFIP SFP SFT_h SIA SIS STF

1 Approbation du compte rendu de la réunion du 23 mars

Le compte rendu du 23 mars est accepté avec la modification suivante

Alinéa 3.3 3e ligne

lire est acceptée par les participants, au lieu de est acceptée par certains participants.

2 Coopération possibles

2.1 Commissions thématiques

Une liste des commissions thématiques a été établie. Elle sera tenue à jour. Toutes les sociétés savantes n'ayant pas des groupes de travail, cette liste s'intitule thématiques dans les sociétés savantes

Les sociétés savantes l'ayant en leur possession, les contacts directs bilatéraux ou multilatéraux peuvent être pris à la demande, en particulier pour l'organisation des journées ou manifestations communes.

La création d'un site internet commun sera étudiée par la SFV. Cette possibilité d'avoir un intranet matériaux sorte de superstructure qui prend en charge l'information relative aux associations scientifiques sera un premier pas vers un rassemblement des sociétés savantes. En attendant la création de ce site internet, une liste papier des manifestations des sociétés prévues ou prévisibles jusqu'en 2002 pourrait être tenue par la SF2M, à condition qu'elle reçoive les éléments des autres associations.

2.2 Colloque matériaux (2002) Participation des associations

Cette idée d'organiser en 2002 un grand colloque matériaux a été acceptée lors de notre réunion du 23 mars. L'adhésion des sociétés a été demandée dans le C.R. de cette réunion. Le signifier explicitement ou lors de notre prochaine réunion est nécessaire pour commencer sa préparation d'ici la fin de l'année. La participation importante des associations permettrait d'avoir un grand nombre de sessions parallèles ; une exposition devrait avoir lieu. Gérard Beck signale que deux sites ont déjà été proposés à Lyon et Toulouse.

3 Étude sur les matériaux pour le compte du MENRT

La proposition de faire réaliser l'étude sur le programme matériaux par les sociétés savantes a été transmise au MENRT. Une réponse est attendue. La lettre d'envoi est examinée. Elle doit être corrigée pour tempérer le rôle de la SF2M et pour insister sur la participation effective des sociétés savantes. Ces remarques seront prises en compte dans la relance à effectuer, ainsi que celles que les participants auront formulées à Jean-Pierre Chevalier avant le 14 mai.

Un cabinet de consultants Algoe a été contacté ; une première réunion a eu lieu le 2 avril et une proposition de contrat formulé. Avec cet organisme sera mis au point une analyse stratégique et une grille de travail. Il faut bien voir que ce sont les sociétés savantes qui vont travailler car l'organisation de l'étude est la suivante

Le comité de pilotage (C.P.) comprend les personnes qui engagent leur société, c'est-à-dire à peu près celles présentes à notre réunion. Un comité technique (C.T.) comprendra de l'ordre de 7 à 8 personnes, choisies parmi celles que les sociétés auront précisées à Jean-Pierre Chevalier dès que le feu vert aura été donné (CECM 15 rue Georges Urbain 94407 Vitry-sur-Seine Cedex Tél. : 01.46.87.35.93 Fax : 01.46.75.04.33 Mél : chevalier@glvt-cnrs.fr).

La grille de travail définie par le C.T. et Algoé, sera approuvée par le comité de pilotage. Elle sera transmise aux sociétés savantes qui travailleront à l'établissement d'un rapport. Cette première synthèse sera étudiée par ALGOE et le C.T., puis examinée par le C.P.. Elle sera renvoyée aux sociétés savantes qui l'amèneront pour avoir un rapport final approuvé par ALGOE, le C.T. et le C.P. Les sociétés s'organisent donc en interne pour répondre à cette demande; les experts sont les sociétés.

Actuellement 15 sociétés ont donné leur accord pour participer. Les 15 autres seront relancées ; la plupart d'entre

elles se doivent de participer, en tant que sociétés des matériaux ; une réponse leur sera demandée (une liste est jointe).

Nous espérons que le MENRT nous confiera cette étude qui est une démarche novatrice et qui met en valeur le rôle que peuvent jouer les sociétés savantes qui sont capables de travailler en groupe.

4 Prochaine réunion

La prochaine réunion est fixée au lundi 21 juin 16 heures. Le lieu sera précisé ultérieurement.

Le Secrétaire Général : Y. FRANCHOT

Liste des sociétés (15) ayant donné leur accord pour participer aux travaux MENRT

AFM	<u>Association Française de Mécanique</u>
ANRT	<u>Association Nationale de la Recherche Technique</u>
CEFRACOR	<u>Centre Français de Anti-CORrosion</u>
GFC	<u>Groupe Français de la Céramique</u>
GFCC	<u>Groupe Français de la Croissance Cristalline</u>
GFEC	<u>Groupe Français d'Etudes des Carbones</u>
GFP	<u>Groupe Français des Polymères (Division de la SFC)</u>
MECAMAT	<u>Groupe Français de MECANique et MATériaux</u>
RFM	<u>Réseau Français de Mécanosynthèse</u>
SFC	<u>Société Française de Chimie</u>
SFGP	<u>Société Française du Génie des Procédés</u>
SF2M	<u>Société Française de Métallurgie et de Matériaux</u>
SFμ	<u>Société Française des Microscopies</u>
SFV	<u>Société Française du Vide</u>
SIS	<u>Société des Ingénieurs Scientifiques et Techniciens en Soudage</u>

Autres sociétés (15)

AAAF	<u>Association Aéronautique et Astronautique de France</u>
AMAC	<u>Association des Matériaux Composites</u>
ATF	<u>Association Technique de la Fonderie</u>
ATTT	<u>Association Technique de Traitement Thermique</u>
CEM	<u>Cercle d'Etudes des Métaux</u>
COFREND	<u>Confédération Française des Essais Non Destructifs</u>
DYMAT	<u>Association pour la promotion de études du comportement Dynamique des Matériaux</u>
GAMAC	<u>Groupement pour l'Avancement des Méthodes d'Analyse des Contraintes</u>
SCI	<u>Société de Chimie Industrielle</u>
SFEN	<u>Société Française d'Énergie Nucléaire</u>
SFIP	<u>Société Française des Ingénieurs des Plastiques</u>
SFP	<u>Société Française de Physique</u>
SFTh	<u>Société Française des Thermiciens</u>
SIA	<u>Société des Ingénieurs de l'Automobile</u>
STF	<u>Société Tribologique de France</u>

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ANNONCE DE CONGRES ET / OU ECOLES
CONGRESS AND SCHOOL ANNOUNCEMENTS

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E_MRS - Spring Meeting

1 - 4 Juin 1999 - Strasbourg - France
Web Site <http://www-emrs.C-strasbourg.fr>
Symposium A : Phot - Excited Process and Applications
Symposium B : Protective Coating and Thin Films 99
Symposium C : Progress in Computational Materials Science
Symposium D : Plasma and Ion Surface Engineering
Symposium E : Advanced Silicon Substrates
Symposium F : Process induced defects in Semiconductors
Symposium G : Material Physics Issue and Applications on Magnetic Oxides
Symposium H : Strain in Materials : Analysis, Relaxation and Properties
Symposium I : Microcrystalline and Nanocrystalline Semiconductors
Symposium J : Materials for Coherent Optics
Symposium K : Materials, Process and Technology for Optical Interconnect
Symposium L : Ab - Initio Approaches to Microelectronics Materials...
Symposium M Basic Models to enhance Reliability in Si based devices and ..
Symposium N : Molecular Optoelectronics : Materials, Physics and Devices
Symposium O : Chalcogenide Semiconductors for Photovoltaics
Symposium P : Optical Characterization of Semiconductor layers and Surfaces

JRFM'99

4èmes Journées du RFM
2 & 3 Juin 1999 - Dijon - France
Web Site : <http://www.bls.fr/amatech> - Web SubSite : Sciences

**Nanostructured Materials Symposium at the 5th IUMRS International Conference
on Advanced Materials
(IUMRS - ICAM'99)**

Beijing - Chine - 13 - 18 Juin 1999
Contact : Kelu@imr.ac.cn
WebSite - <http://www.chimeb.edu.cn>

PM2 Tec 98

1999 International Conference
on Powder Metallurgy and Particulate Materials
Vancouver - 20 / 24 Juin 1999
E-Mail : Info@mpif.org - Website: www.mpic.org

NATO Advanced Research Workshop on Nanostructured Films and Coatings

June 29-30, 1999 - Santorini, Greece
(Contacts: G.M. Chow, Department of Materials Science, National University of Singapore, Kent Ridge, Singapore 119260, FAX: +65-7763604, EMAIL: mascgm@nus.edu.sg; I. Ovid'ko, Institute of Problems for Mechanical Engineering, Russian Academy of Sciences, Bolshoj 61, Vas. Ostrov, St. Petersburg 199178, Russia, FAX: +7-812-2178614, EMAIL: ovidko@def.ipme.ru; T. Tsakalakos, Rutgers University, Department of Ceramics and Materials Engineering, Piscataway, NJ 08854, FAX: 732-445-3229, EMAIL: tsakalak@rci.rutgers.edu)

4th Int. Conf. on Materials Chemistry

13 - 16 Juillet 1999 - Trinity College _ Univ. Dublin - Irlande
Web Site : <http://www.rsc.org/conferences>

Themes :

- Inorganic Nano and Micro Particles
- Functional Polymers
- Magnetic Materials
- Organic Nanostructures
- Molecular Crystals and Crystal Engineering
- Computational Chemistry and Materials for Electronic

Advanced Materials - Nanostructured Systems

15 - 17 Juillet 1999 - Hong Kong
1st workshop of the new IUPAC series :
"New Directions in Chemistry
Theory, Nanoparticles, Quantum Dots,
Bio - Inspired Structures, Applications to Nanotechnology
Organizing Committee A. El - Sayed - Georgia Tech - Atlanta - USA
J. Portner - President of IUPAC - Tel Aviv - Israel

N. Teng Yu - HKUST - Hong Kong
S. Williams - Hewlett - Packard Co., California USA
Web Site : <http://www.iupac.org/symposia/conferences/wam1>

NATO Advanced Research Workshop
Investigations and Applications of Severe Plastic Deformation
2 - 6 Aout 1999 - Moscou - Russie
E-Mail : TLow@lanl.gov and Valiev@ippm.rb.ru

IAC - 2
2nd International Alloy Conference
8 - 13 Aout 1999 - Davos - Suisse
Website : www.engfnd.org

"Thermal Spray Processing of Nanoscale Materials II"
15 - 20 Aout, 1999 - Quebec City, Canada
(Contacts: C.C. Berndt, SUNY-Stony Brook, 306 Old Engineering, Stony Brook,
NY 11794-2275, FAX: 516-632-8525, EMAIL: cberndt@notes.cc.sunysb.edu,
WEBSITE: <http://www.engfnd.org>; E.J. Lavernia, EMAIL: lavernia@uci.edu; C.
Moreau, EMAIL: christian.moreau@nrc.ca; M.L. Trudeau, EMAIL:
trudeaum@ireq.ca; and L. Kabacoff, EMAIL: kabacol@onr.navy.mil)

NANO 2000
5th International Conference on Nanostructured Materials
Sendai - 20 - 25 Aout 2000
E-Mail : nano2000@imr.tohoku.ac.jp

RQ10
10th International Conference on Rapidly Quenched and Metastable Materials
Bangalore - Inde - 23 - 27 Aout 1999
Website : <http://www.metalrg.iisc.ernet.in/rqten/>

ISMANAM 99

International Symposium on Metastable Mechanically Alloyed and Nanocrystalline Materials
and Euro Conference on Gas Phase Synthesis of Nanocrystalline Materials.

Org. : L. Schultz, J. Eckert, H. Hahn
Dresden - 30 Aout - 3 Septembre 1999
E-Mail : ISMANAM99@ifw-Dresden.de
WebSite: <http://www.ifw-dresden.de/imw/ismanam/>

NOUVEAU

EUROSOLID

6 - 10 Septembre 1999 - Carry le Rouet - France

SMM14

14th International Conf. on Soft Magnetic Materials
8 - 10 Septembre 1999 Balatonfüred - Hongrie
web site : <http://www.kfki.hu> - Subsite : smm14

EUROMAT 99

20 - 30 Septembre 1999 - Munich- Allemagne
E-Mail : euromat@dgm.de
Web Site : <http://www.euromat.fems.org>

Elaboration et Transformation des Solides Divisés

(Ecole Thématique)
21 - 24 Septembre 1999 Carry le Rouet - France
Renseignements : F. Gruy - ENSM St Etienne
E-Mail : gruyemse.fr

Int. Symp. Cluster and Nanostructure Interfaces (ISCANI)

25 - 29 Octobre 1999 - Richmond USA
website : <http://www.vcu.edu/ISCANI/>

J.A. 99 / SF2M

2- 5 Novembre 1999 - ENSAM / Paris - France
Les matériaux pour les microactionneurs et microcapteurs
Les mécanismes de renforcement dans les polymères & élastomères
Matériaux Magnétiques de Grande Diffusion
Tribologie, Contact Métal - Outil lubrifiant en laminage à froid
Surface et Interface Métallique
Surface et Revêtement
Solidification
Les Imageries de l'angstrom au micron
Les Matériaux pour le Bâtiment
Adresse : SF2M - 1 Rue de Craiova - 92024 Nanterre Cedex

EURO PM99

3rd European Conference on Advances in Hard Materials Production
8 - 10 Novembre 1999 - Turin - Italie
Web site : <http://www.epma.cm>

MRS Fall Meeting 99

29 Novembre - 3 Décembre 1999 - Boston MA - USA
Website : <http://www.mrs.org>

Sintering 2000

7th International Conference on Sintering
Sintering Science and Technology beyond 2000AD
22 - 25 Février 2000 - New Delhi - Inde
E-Mail : gsu@iitk.ac.in

JRFM'2000

23 - 24 Mai 2000 - Bordeaux France
Wbsite : <http://www.bls.fr/amatech>

4th EUROMECH

26 - 30 Juin 2000 - Metz - France
E-Mail : euromech@lpmm.univ-metz.fr
WebSite : <http://www.lpmm.univ-metz.fr/euromech>

III European Conference on Fluidization

29 - 31 Mai 2000 - Toulouse - France
E-Mail : Progep@ensigct.fr

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Annonces de Soutenance de Thèses
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Caractérisation et réactivité de la surface de poudres nanométriques d'oxydes métalliques: Analyse par spectrométrie IR-TF et application à l'étude des mécanismes de détection de gaz par capteurs résistifs.

Jérôme Tribout - Université de Limoges, Limoges, France, 14 décembre 1998.
Directrice: Marie-Isabelle Baraton

=====
Distinct Element Modelling of a Planetary Ball Mill
=====

M.P. Dallimore - Dpt of Mechanical and Materials Engineering - University Western Australia - Australie

Synthèse et Propriétés de Ferrites Nanométriques : Influence de l'énergie de surface sur les propriétés structurales et magnétiques de ferrites de titane synthétisés par chimie douce et mécanosynthèse

N. Guigue - Millot - 26 Novembre 1998 - LRRS UMR 5613 CNRS - Univ. Bourgogne - Dijon - France
Jury : J. Etourneau, A. Rousset, G. Bertrand, D. Stuerger, G. Le Caër, M. Guyot, O. Isnard, P. Perriat

Transformations antiferromag - ferromag - paramagnétiques - verre de spin dans les alliages de Fe Rh nanocristallisés par Broyage

E. Navarro - Université de Complutense - Madrid - Espagne - 18 Mai 1998
Co directeurs : A. Hernando - A.R. Yavari

=====
Modifications morphologiques et microstructurales du matériau actif des cathodes de batteries à l'ion lithium induites par broyage et traitement thermique

Ph. Perrot - Université de Poitiers - 6 Mai 1998

Co - Directeurs : E.L. Mathe, M. Grosbras

Jury : J. Mimault, H. Van Damme, A. Dager, M. Broussely, P. Goudeau, E.L. Mathe, M. Grosbras

=====
Effects of the mechanical milling on carbons : negative electrode materials of Li - ion batteries"

F. Salver Disma - Université de Picardie Jules Verne - 4 Février 98

Jury : Aymard L., Beguin F., Coulon M., Furdin G, Lassegues JC, Percheron Guegan A., Rouzaud JN, Tarascon JM.

=====
"Elaboration et Caractérisations de Cermets Alumine - Métal à partir de poudres obtenues par Mécanosynthèse"

J.-L. Guichard - INPL - Nancy - 23 Janvier 1998

Jury : A. Simon, C. Carry, F. Thévenot, G. Le Caër, A. Mocellin

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Sites internet à découvrir
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Site sur la cristallographie / Soft + Littérature

<http://www.lmcp.jussieu/sincris-top/logiciel>

N.B. : si vous connaissez d'autres sites en relation avec les thèmes développés par le RFM, faites nous les connaître

Cooperative Research on Related Areas

COREE du SUD (6 May 1999)

From Professor Soon B. Hong
Department of Materials Science and Engineering
Korea Advanced Institute of Science and Technology
373 - 1 Kusung - dong, Yusung - gu
Taejon 305 - 701 Korea

One research topic is entitled "Mechanical Behavior and Wear Resistance of Nanocrystalline WC - Co alloy". We are investigating the fabrication process, sintering and mechanical & wear properties of nanocrystalline WC - Co hard materials. The other research topic is titled "Fabrication Process and Mechanical Properties of Mechanically Alloyed Tungsten Heavy Alloys". We are investigating the mechanical alloying process, sintering behavior and mechanical properties of MA tungsten heavy alloys.

We are very pleased to discuss for international cooperative research on above research topics with Member of Mecanosynthese Group

E-Mail : ShHong@Sorak.kaist.ac.kr

Ph D Position and Post Doc Position Proposals

ISRAËL (14/5/99)

A postdoctoral position is available at the High-Pressure group of the School of Physics & Astronomy, Tel Aviv University. This position is available starting with the 1999/2000 academic year for one year, with a possible extension for two years. For additional information, please contact Moshe P. Pasternak by email to hh136@post.tau.ac.il or visit the MEDC web site (www.unca.edu/medc).

Denmark (22/02/99)

One Ph.D. position will be available in the department of Physics at the Technical University of Denmark from 1st April 1999. The candidate will work in the area of Crystallization Kinetics in Bulk Metallic Glasses, which is associated with a Talent Project supported by the Danish Research Council. The position is for three years, and monthly salary is about 20,000 Dkr (3300 USD). Applications including a CV, publication list, and names of three references should be sent as soon as possible to:

Assoc. Prof. Jianzhong Jiang
Department of Physics, Building 307
Technical University of Denmark
DK-2800 Lyngby, Denmark
e-mail jiang@fysik.dtu.dk
fax. +45 45 93 23 99
tel +45 45 25 31 65

Québec (CANADA) (22/01/99)

Institut National de la Recherche Scientifique
Département ...nergie et Matériaux

POST-DOCTORAL POSITION IN Ni-MH BATTERY TECHNOLOGY

Candidates will be interested in developing a research project focused on the study of new materials for use as negative electrode in nickel-metal hydride (Ni-MH) batteries. Mg-based compounds as electrode material and high-energy ball milling as synthesis method will be privileged. Particular efforts will be performed in order to clarify the correlation between the structure, the composition and the morphology of the alloy and its electrochemical performances.

Experience in electrochemistry and materials science is essential, a working knowledge of Ni-MH battery is an advantage.

Applicants must have obtained their Ph-D between July first, 1996 and January first, 2000.

The work will start between June 1st, 1999 and May 31, 2000.

Initial appointment is for one year, renewable for one year. Salary is \$28,000/year, which could be increased with qualifications and experience.

Applicants should send a CV including a list of publications before March 1st, 1999 to:

Pr. Lionel ROUE
INRS- Energie et Matériaux
1650, bd. Lionel Boulet
Varenes, Québec, CANADA
J3X 1S2

E-Mail: [HYPERLINK mailto:roue@inrs-ener.uquebec.ca / roue@inrs-ener.uquebec.ca](mailto:roue@inrs-ener.uquebec.ca)•

USA (17/12/98)

Rutgers University is seeking a postdoctoral associate with demonstrated expertise in mechanochemistry to work on research focused on biomaterials. The candidate must be able to work on research focused on biomaterials. The candidate must be able to work as part of multidisciplinary team involving industry and academia focused on making biomedical implant devices. The candidate should demonstrate the ability to work independently, publish in archival journals and present their work in a public forum. The candidate should send a curriculum vitae, three representative publications (preferably with the candidate as a first author) and the names, address, email and phone numbers of three references that can comment on the candidate's capabilities. The position is available immediately at a salary of \$32,000 with health benefits included. The position will be posted until a suitable candidate is identified. Interested candidates should send correspondence to

Professor R.E. Riman
Rutgers University
Department of Ceramic and Materials Engineering
607 Taylor Road
Piscataway, NJ 08854 - 8065
Riman@alumina.rutgers.edu

Bibliographie Récente

Livres ou "Special Issues"

"Non Equilibrium Processing of Materials"

R.W. Cahn - Elsevier Science - Volume 2 in the Pergamon Materials Series

A large number of technical papers have been published in reviews, monographs and conference proceedings, but have almost always been devoted to a single processing technique. This book, however, covers all the non equilibrium processing methods and their effects in a single volume.

web site : www.elsevier.nl/locate/isbn/0080426972

Bulk Amorphous Alloys : Preparation and Fundamental Characteristics

A. Inoue

Materials Science Foundation Vol. 4 - Trans Tech Publications : <http://www.ttp.net>

Interest in bulk amorphous alloys has increased rapidly throughout the world and these materials have now gained a position of great importance in basic science and engineering materials technology. Bulk amorphous alloys based upon the Zr - Al - Ni - Cu, Zr (Ti,Nb) - Al - Ni - Cu and Zr - Ti - Ni - Cu - Be systems have already achieved wide commercial success as components of various technical accessories ranging from sporting goods to optical instruments.

Here is a state of the art reviews on this new group of materials, covering all areas of interest, ranging from the synthesis of these special alloys and their fundamental properties, to their engineering characteristics and applications.

This work will therefore be of equal interest to those who wish to become fully acquainted with the subject, and to those who are already actively engaged in the field.

DISPERSION-STRENGTHENED ALUMINIUM PREPARED BY MECHANICAL ALLOYING

Michal Besterčí, Institute of Materials Research, Slovak Academy of Sciences, Kosice

In the book, the author describes the theoretical and technological fundamentals of mechanical alloying the Al-C system. Special attention is given to material characteristics, the kinetics and mechanism of mechanical alloying, methods of mixture compaction and heat treatment of compacted parts. Models of dispersoid spatial arrangement, dispersoid evaluation and optimisation and experimental possibilities are discussed. The interpretation of the static and dynamic mechanical properties, especially strength and ductility properties at 20 °C, mechanical properties at elevated temperatures are discussed, with emphasis on the effect of interface, superplasticity, creep and creep-fatigue characteristics. Content

Introduction

1. Characteristics of dispersion-strengthened systems 2. Mechanical alloying (kinetics and mechanism of preparation of the Al-C system by mechanical alloying; compaction of powders and heat treatment of compacts;

3. Microstructure and quantitative evaluation of parameters of dispersion-strengthened materials (definition and properties of interparticle distance; experimental possibilities of determination of structural objects; models of heterogeneous structures and their evaluation; simulation of model structures; analysis of the spatial distribution of particles in the Al-Al4C3 material) 4. Static and dynamic mechanical properties (mechanical properties at elevated temperatures;

mechanical properties at 20°C; effect of interface on the mechanical properties; superplastic properties of the system; thermal stability of the system; creep characteristics; creep-fatigue characteristics)

References

Index

ISBN 189832655X, 80 pages, 234×156 mm, soft laminated cover, £22.00, January 1999

Cambridge International Science Publishing 7 Meadow Walk, Great Abington, Cambridge CB1 6AZ, England Fax

+44 1223 894539; Tel +44 1223 893295 Email: cisp@cisp.demon.co.uk

<http://www.demon.co.uk/cambsci/homepage.htm>

"Mechanical Alloying"

Auteurs : Li Lü & Man On Lai(National University of Singapore)

Kluwer Academic Publishers

Contents : Preface - Introduction to Mechanical Alloying - Experimental Set - Up - The Mechanical Alloying Process - Formation of New Materials - Characterization of Powders - Densification - Mechanical Properties - Mechanisms of Mechanical Alloying - Modeling of Mechanical Alloying - Index

"Surface-Controlled Nanoscale Materials for High-Added-Value Applications"

Editors: Kenneth E. Gonsalves, Marie-Isabelle Baraton, Rajiv Singh, Heinrich Hofmann, Jerry X. Chen, and Joseph A. Akkara.

Materials Research Society, Symposium Proceedings Volume 501, 1998

MRS, Warrendale, Pennsylvania, USA (website: <http://www.mrs.org/>)

"Nanomatériaux"

Auteurs : E. Gaffet, S. Begin - Colin, O. Tillement

Editeur : Innovation 128 - 24 Rue du Quatre Septembre - 75002 Paris - France - Fax : 33 1 42 65 47 76

Les dernières années ont vu apparaître dans le monde des matériaux avancés le préfixe "nano" (nanostructuré, nanocristallins, nanophase ou nanométrique) ; les conférences et les forums sur Internet se multiplient où s'échangent des informations sur les avancées scientifiques et technologiques dans ce domaine des matériaux nanostructurés qui se distinguent des matériaux polycristallins conventionnels par la dimension des cristallites les composant ou par la dimension des hétérostructures présentes : ces dimensions sont de quelques dizaines d'angströms, voire de quelques nanomètres. A ces dimensions, les propriétés des matériaux changent radicalement.

Au début des années 90, les japonais ont été les premiers à lancé d'ambitieux programmes de R & D puisque le MITI a consacré aux nanomatériaux près de 200 millions de dollars pour la période 1990 - 2000 et que la Science & Technology Foundation a investi presque la même somme pour co - financer des projets de laboratoires publics et privés. Les Etats Unis puis les pays européens ont investi plus tardivement mais déjà ont obtenu des résultats prometteurs (.....) Certaines applications existent déjà au niveau international, quelque 400 sociétés se partagent aujourd'hui un marché voisin de 1 milliard de dollars mais qui devrait tripler, voire quintupler à l'horizon 2001.(.....)

(...) Pour aider les industriels concernés à imaginer les applications qu'ils pourraient s'approprier et identifier les acteurs internationaux, la présente étude dresse un état de l'art complet des nanomatériaux en décrivant leurs procédés d'élaboration actuels ou envisagés et en détaillant leurs différentes propriétés physico - chimiques et les géométries que l'on peut obtenir.

Enfin l'étude permet de cerner les applications actuelles et potentielles...

CHEMISTRY FOR SUSTAINABLE DEVELOPMENT Vol. 6, No. 2-3, MARCH-JUNE 1998

Proceedings of 2d International Conference on Mechanochemistry
(INCOME-2), which was held in Novosibirsk in 1997.

Contact : Prof. • N.Z. Lyakhov, Inst. Sol. State Chem.- Russian Acad Sci. - Kutaleladze, 18 - Novosibirsk - 630128 Russia - The Proceedings will be available by the price 80 USD.

Mechanochemistry of Materials Cambridge International Science Publishing

Emmanuel Gutman - Materials Eng. Dpt - Ben Gurion University - Beer Sheva - Israel

Considerable advances have been made in mechanochemistry in the last couple of decades. Training of experts in this field with a background in materials science, chemical and mechanical engineering, etc. requires study of the fundamentals of mechanochemistry. There is a need for a textbook in the general and compressed form which would cover many aspects and would be used as a basis for understanding the fundamental principles to control mechanochemical phenomena. This textbook is based on lectures given by Prof. Gutman in a graduate course in the mechanochemistry of materials at the Ben - Gurion University of the Negev. The book contains examples of experimental results to illustrate the mechanochemical phenomena and technologies.

BIBLIOGRAPHY ON MECHANICAL ALLOYING AND MILLING

Suryanarayana (Inst for Materials and Advanced Processes, University of Idaho, USA)

The present bibliography covers information on mechanical alloying and milling of materials starting from 1970 (when it was recognized that MA has become a commercial/viable material processing technique instead of just a grinding method) to 1996. All the available references will be presented in a chronological fashion. Under each year, (.....)

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Proceeding du Congrès "Mechanically Alloyed, Metastable and Nanocrystalline Materials"- Barcelone (1997)

Editor : M.D. Baro, S. Surinach - Materials Science Forum 269 - 272 (1998)

PERIODIQUES

(Rubrique réalisée grâce aux moyens de la bibliothèque de
l'Université de Technologie de Belfort - Montbéliard / UTBM)

[42] RESIDUAL STRAIN IN POWDERS OF LI(2)-(ALMn)(3)TI TITANIUM TRIALUMINIDE WITH ADDITIONS OF ZR, GA, AG OR V [JAPANESE]

Kimura T. Yamamoto Y. Hashimoto K. Moriya H. - Journal of the Japan Institute of Metals. 63(2):174-178, 1999
After heat-treatment at 1450 K for 24 h, Li(2)-(AlMn)(3)Ti titanium trialuminides with and without quaternary elements of Zr, Ga, Ag or V were examined by X-ray powder diffraction profile analysis and optical and scanning electron microscopy after hardness tests. The minimum load for crack generation during the hardness measurements decreased with the addition of Ag or Zr, however the minimum load increased with addition of V. The residual strain which was induced during milling of the alloy into powder exhibited a positive correlation with the minimum load, i.e., while the alloys with V showed a large residual strain, the alloys with other quaternary elements exhibited a smaller residual strain than that of the ternary Li(2)-type (AlMn)(3)Ti alloy. The composition dependence of the ternary Li(2)-(AlMn)(3)Ti single phase alloys was examined by the above mentioned method. It was shown that the residual strain has the maximum value near the center of Al and Mn-rich corner of the single phase region in isothermal ternary phase diagram at 1425 K.

[41] FORMATION OF Y2O3-AL2O3 MIXED OXIDE PHASES IN SOLID SOLUTION NI-BASE ODS ALLOYS [JAPANESE]

Nishi K. Hirano T. Arai M. Aono Y. - Journal of the Japan Institute of Metals. 63(2):259-268, 1999
A study has been conducted to examine the formation behavior of mixed oxide phases in some solid solution type Ni-base ODS alloys made by MA using TEM, XRD and DTA technique. The results indicate that the mixed oxidized YAlO₃ phase, having a hexagonal structure and termed as YAH, formed when heating Ni-20Cr-0.3Al-0.6Y(2)O(3)(mass%) alloy up to 1173 K. The nano-electron beam diffraction experiments identified that the mixed oxide was uniform in structural aspect. NiO has a facilitative effect on forming PAH type mixed oxide and the ratio of the Y₂O₃ to Al₂O₃ has a profound effect on the crystalline structure type of the mixed oxide. The PAH mixed oxide in Ni-20Cr-0.3Al-0.6Y(2)O(3) was stable to higher temperature than that in Ni-5Al-10Y(2)O(3)-NiO alloys. The present study suggests that the formation and the stability of mixed oxides were strongly affected by the components of ODS alloys and the impurity oxygen absorbed in materials.

[40] INFLUENCE OF MILLING CONDITIONS ON THE MECHANICAL ALLOYING OF FE-B POWDERS

Yang YZ. Li QS. Zhu YL. Ma XM. Dong YD. - Journal of Materials Science & Technology. 15(2):137-142, 1999
Amorphous and nanostructural Fe-B alloys made by mechanical alloying of elemental Fe and amorphous B powders have been studied using X-ray diffraction, differential scanning calorimetry and Mossbauer spectroscopy. It has been shown that the milling conditions have a strong effect on the alloying. The single phase amorphous alloy, which is limited at nominal composition of Fe₆₀B₄₀, has been produced only by milling in Ar atmosphere and in other composition range the mixture of nanostructure Fe-like phase and Fe₂B compound with a little amorphous phase are obtained. While by milling in air atmosphere the introduction of oxygen in air may suppress the formation of amorphous phase, thus the compounds Fe₂B may be synthesized with no trace of amorphous phase. The crystallization temperatures of amorphous phase in the resultant products are higher than those of a single amorphous alloy Fe₆₀B₄₀, and hardly independent of the milling conditions and the composition. In addition, it is revealed that detectable B content in the final products is lower than the nominal composition of all the initial samples, which indicates that some B atoms may be located in the disordered interfacial regions of the nanostructural alloyed mixtures.

[39] SIMULTANEOUS AUTOGENOUS MILLING AND FERRIC CHLORIDE LEACHING OF CHALCOPYRITE

Maurice D. Hawk JA. - Hydrometallurgy. 51(3):371-377, 1999
Mechanical activation by autogenous milling has previously been shown to improve leaching kinetics. In this study autogenous milling was conducted simultaneously with ferric chloride leaching. A sequence of products was observed, with chalcopyrite being replaced by synthetic nantokite (CuCl) and the nantokite being more gradually replaced by synthetic eriochalcite (CuCl₂ · 2H(2)O).

[38] PHASE RELATIONS AT 1500 DEGREES C IN THE TERNARY SYSTEM ZrO2-Y2O3-TiO2

Feighery AJ. Irvine JTS. Fagg DP. Kaiser A. - Journal of Solid State Chemistry. 143(2):273-276, 1999
Phase relations at 1500 degrees C in the ternary system ZrO₂Y₂O₃-TiO₂ have been determined by powder X-ray diffraction of samples prepared by standard solid state mixing and also by ball milling. A large region of this ternary oxide system was shown to exhibit the defect cubic fluorite structure and to encompass compositions containing very high oxygen vacancy concentrations up to 16%, e.g., Zr_{0.21}Y_{0.62}Ti_{0.17}O_{1.69}. We have accurately determined the maximum extent of the defect fluorite phase, at low concentrations of yttrium/high concentrations of titanium. From previous studies this region of the solid solution is expected to yield compositions which exhibit the optimum mixed ionic and electronic conducting properties for electrochemical applications. We have determined that at 1500 degrees C up to 18 atom% Ti⁴⁺ can be dissolved into ZrO₂ stabilized in the cubic fluorite structure by the presence of 14 to 20 atom% Y. Trends in composition and unit cell parameter are discussed.

[37] NMR MEASUREMENTS IN MILLED GDCO2 AND GDFE2 INTERMETALLIC COMPOUNDS

Tribuzy CVB. Biondo A. Larica C. Alves KMB. Guimaraes AP. - Journal of Magnetism & Magnetic Materials. 195(1):49-56, 1999

We have used the nuclear magnetic resonance technique to study the magnetic and structural properties of the Gd-Co and Gd-Fe metallic systems, starting with the C15 Laves phase intermetallic compounds, and submitting them to a high-energy milling process. This leads to the amorphization of the samples, as determined by the X-ray diffraction spectra. For the Gd-Co system the NMR study used the Co-59 nucleus; in the Gd-Fe system, Gd-155, Gd-157 and Fe-57 were used. Both systems showed segregation of the pure elements, after a few hours of milling. In the Gd-Co

system, a single line, of increasing width, was observed in the Co-59 spectrum. In the Gd-Fe system, the (155)Gd and Gd-157 resonances show three lines, arising from electric quadrupole interaction. With increasing milling time, the lines broaden, and extra lines appear attributed to a cubic phase of Gd; this interpretation is supported by the X-ray analysis of the samples. The Fe-57 NMR spectrum of this system also informs on the direction of magnetization of the samples in the early stages of milling. From 1 to 7 h of milling, a spectrum of alpha-Fe was observed. The study of the NMR line intensity as a function of radio frequency (RF) power in GdCo₂ suggests the existence of regions of the samples with different degrees of disorder. We have observed the persistence of NMR signals from the original intermetallic compounds in the samples with up to 10 and 7 h of milling, respectively, for GdCo₂ and GdFe₂.

[36] ON A PHASE TRANSFORMATION PRODUCED BY MECHANICAL ACTIVATION IN IRON PYRITE

Eymery JP. - European Physical Journal-Applied Physics. 5(2):115-121, 1999

The behaviour of pyrite in the process of mechanical milling in air has been examined. Milled powders were characterized by scanning electron microscopy, Mossbauer spectroscopy working in transmission geometry and X-ray diffraction. In the presence of oxygen, pyrite can readily be transformed to ferrous sulphate monohydrate, which indicates that the Fe(II) goes from a low-spin state to a high-spin state. The transformation mechanism is saturated after about 60 hours milling, but however it can be markedly prolonged by further ageing at room temperature. The results also indicate that mechanical milling is a useful room temperature process of material production.

[35] MOLECULAR ORBITAL CALCULATION OF GRAPHITE K-V X-RAY EMISSION SPECTRA

Kaneyoshi T. Kowada Y. Tanaka T. Kawai J. Motoyama M. - Spectrochimica Acta Part B-Atomic Spectroscopy. 54(1):189-196, 1999

The DV-Xa molecular orbital (MO) calculation method has been applied to the carbon K-V X-ray emission spectra of graphite. The calculated 2p density of states (DOS) of a larger model cluster, which avoided the influence of dangling bonds of the cluster edge, was in excellent agreement with the X-ray emission spectra. The calculated pi and a subbands of 2p DOS explained the polarized behavior of the spectra. The orientation of graphite was quantitatively discussed by means of polarization of the spectra. These results were applied to the analysis of the structural change of mechanical milled graphite; the structure change of the ball-milled graphite was studied by the X-ray spectroscopy and MO calculation. It was shown that the refinement of graphite powder occurred for up to 1000 h of milling, keeping the graphite structure, and that a further milling changed the C-C bonding within the graphite layer network.

[34] X-RAY SPECTROSCOPIC ANALYSIS OF SOLID STATE REACTION DURING MECHANICAL ALLOYING

Yamada K. Takahashi T. Motoyama M. - Spectrochimica Acta Part B-Atomic Spectroscopy. 54(1):197-203, 1999

Niobium or tungsten and graphite powders were mechanically alloyed. Carbon K X-ray spectra of the mechanically alloyed powders were measured using an electron probe microanalyzer (EPMA) in order to investigate the solid state reaction process. In the early stage of the mechanical alloying (1-2 hours), graphite did not react with metal, but particle size of graphite became smaller. In the next stage of the mechanical alloying (10 hours), micro-crystalline graphite powder reacted with metal. Polarization of the X-rays were measured for Nb₂C and W₂C, because a single crystal WC emitted polarized X-rays. The measurement of X-ray emission spectra was useful for the structural and chemical analysis of mechanical alloying reaction processes.

[33] EFFECT OF PRELIMINARY MECHANICAL ACTIVATION OF POLYACRYLAMIDE IN THE PRESENCE OF METAL ON THERMAL DEGRADATION OF POLYMER

Dmitrieva TV. Sirovatka LA. Bortnitskii BI. - Russian Journal of Applied Chemistry. 71(10):1817-1820, 1998

The qualitative and quantitative composition of volatile products formed in thermal degradation of original and mechanically activated polyacrylamide was studied. The composition and the yields of the volatile products of polymer thermal degradation were analyzed in relation to the nature of metal used in dynamic activation of polyacrylamide.

[32] FINE-POWDERING OF FIBROUS CELLULOSE BY MECHANICAL MILLING [JAPANESE]

Endo T. Kitagawa R. Hirotsu T. Hosokawa J. - Kobunshi Ronbunshu. 56(3):166-173, 1999

Fibrous cellulose was mechanically milled in a vibratory ball mill under several conditions and the obtained powders were characterized. Water or organic solvent adsorbed on amorphous regions of cellulose significantly affected the crystallinity and particle size of the obtained powders. From the vacuum-dried samples which contained < 0.1 wt% water were obtained fine powders with low crystallinity. This may be due to an increase in internal strain of dry cellulose which results in the fragility against a mechanical stress, and due to a decrease in agglomeration of cellulose powders promoted by water. On the other hand, by milling the air-dried samples which contained 7 wt% water at = 100 degrees C were obtained the fine powder with the same particle sizes as in the case of the vacuum-dried samples. These powders exhibited higher crystallinities than in the case of the vacuum-dried samples. This suggests that preferential breaking up of the amorphous regions of cellulose maintains the crystalline regions. Adsorption of organic solvents such as acetone on cellulose induced the finer powders of cellulose with relatively higher crystallinity. The addition of 20 wt% acetone to the vacuum-dried cellulose was most effective for the preparation of the fine cellulose powder.

[31] PARTICULARITIES OF C-60 TRANSFORMATIONS AT 1.5 GPA

Davydov VA. Kashevarova LS. Rakhmanina AV. Agafonov V. Allouchi H. Ceolin R. Dzyabchenko AV. Senyavin VM. Szwarc H. Tanaka T. Komatsu K. -Journal of Physical Chemistry B. 103(11):1800-1804, 1999

The high-pressure states of C-60 fullerene corresponding to the 1.5 GPa isobaric section of its p,T diagram in the 293-1073 K temperature range were investigated by X-ray diffraction and IR and Raman spectroscopies. It was

shown that increasing the treatment temperature of C-60 at quasihydrostatic pressure changes the nature of the polymerization products. The IR and Raman spectra of the high-pressure materials obtained at 423 K are similar to the spectra of the dumb-bell-shaped C60 dimer synthesized in a solid-state mechanochemical reaction of C60 With potassium cyanide by Wang et al.(1) It can be concluded that this dumb-bell-shaped dimer is the main structural unit forming the low-pressure polymerization product. So, on further temperature increase, the dimer phase becomes unstable and transforms into the "low-pressure" orthorhombic polymerized phase of C60 which, in turn, transforms into the tetragonal polymerized phase at temperatures above similar to 723 K. Depolymerization of the polymerized phases at temperatures above similar to 900 K results in the formation of the monomeric fee phase of C60 fullerene, which agrees with the experimental data determined previously by Bashkin et al.(2).

[30] ALPHA-ALUMINA-H2O INTERFACE ANALYSIS BY ELECTROACOUSTIC MEASUREMENTS

Costa AL. Galassi C. Greenwood R. - Journal of Colloid & Interface Science. 212(2):350-356, 1999

In this work an electroacoustic technique was used to characterize the dispersing behavior of alumina in water with or without the addition of an anionic polyelectrolyte as dispersant, Electroacoustic measurements enabled the zeta potential and particle size distribution to be noted; additionally, the in situ measure of the conductivity allows the ionic strength to be simultaneously determined. In this way the pH or dispersant contribution to powder stabilization has been evaluated. With this technique important colloidal parameters such as the isoelectric point and particle size distribution at various solution or powder conditions (alumina vol%, pH, dispersant wt%, milling time) can be measured and the minimum amount of dispersant (Duramax D3021) required to cover completely the powder can be easily estimated.

[29] PHASE FORMATION AND THERMAL STABILITY OF MECHANICAL ALLOYED IRON-TANTALUM

Mertinat M. Herr U. Oelgeschlager D. Samwer K. - Journal of Applied Physics. 85(7):3512-3518, 1999

Iron-rich iron-tantalum solid solutions were prepared by mechanical alloying of elemental powder mixtures. At low Ta concentrations the alloys form a crystalline solid solution with bcc structure. At higher contents additionally an amorphous phase appears. The phase fractions and their compositions were determined by x-ray diffraction and Mossbauer spectroscopy. The thermal stability of the supersaturated solid solutions was investigated by differential scanning calorimetry measurements. Upon annealing, the solid solutions are found to establish a metastable equilibrium by precipitation of the amorphous phase before transformation to the equilibrium phases sets in. The results are discussed on the basis of the phase stabilities of the participating stable and metastable phases. It is concluded that the phase formation in this system during milling can be described by a smeared-out polymorphous transition to the amorphous phase with increasing solute content rather than by a metastable phase equilibrium. The possibility of grain boundary wetting with the amorphous phase is discussed.

[28] HIGHLY CURVED CARBON NANOSTRUCTURES PRODUCED BY BALL-MILLING

Huang JY. Yasuda H. Mori H. - Chemical Physics Letters. 303(1-2):130-134, 1999

The formation of nanoarches or highly curled carbon nanostructures during high-energy ball-milling of graphite is reported. High-resolution transmission electron microscopy indicates that graphite sheets with a thickness of less than 10 nm (dimension along the c-axis) hold high flexibility and are highly bendable, thus forming nanoarches or highly curved nanostructures upon ball-milling. It is evident that these nanostructures are formed by bending the flat sp(2) layers directly under the mechanical deformation.

[27] HYPERCHAOTIC QUALITIES OF THE BALL MOTION IN A BALL MILLING DEVICE

Caravati C. Delogu F. Cocco G. Rustici M. - Chaos. 9(1):219-226, 1999

Ball collisions in milling devices are governed by complex dynamics ruled by unpredictable impulsive forces. In this paper, nonlinear dynamics techniques are employed to analyze the time series describing the trajectory of a milling ball in an empty container obtained from a numerical model. The attractor underlying the system dynamics was reconstructed by the time delay method. In order to characterize the system dynamics the calculation of the spectrum of Lyapunov exponents was performed. Six Lyapunov exponents, divided into two terns with opposite sign, were obtained. The detection of the positive tern demonstrates the occurrence of the hyperchaotic qualities of the ball motion. A fractal Lyapunov dimension, equal to 5.62, was also obtained confirming the strange features of the attractor.

[26] TRANSFORMATION OF CARBON NANOTUBES TO NANOPARTICLES BY BALL MILLING PROCESS

Li YB. Wei BQ. Liang J. Yu Q. Wu DH. - Carbon. 37(3):493-497, 1999

Carbon nanotubes were treated by high-energy ball milling processing for different milling times, and the samples were observed by HRTEM. The broken nanotubes and lots of carbon onion-like particles were obtained in the sample milled for 15 min. When the milling time was up to 60 min, carbon nanotubes turned into amorphous carbon. On the basis of HRTEM observation of carbon nanotubes and carbon nanoparticles, we discuss the possible formation mechanism of nanoparticles under the impact acting as driving force.

[25] SOLID-GAS REACTIONS DRIVEN BY MECHANICAL ALLOYING OF NIOBIUM AND TANTALUM IN NITROGEN

Liu L. Lu L. Chen L. Qin Y. Zhang LD. - Metallurgical & Materials Transactions A-Physical Metallurgy & Materials Science. 30(4):1097-1100, 1999

Solid-gas reactions of niobium and tantalum with molecular nitrogen driven by mechanical alloying (MA) have been investigated by X-ray diffraction, transmission electron microscopy, and differential thermal analysis. It was found that the phase transition followed a sequence of Nb2N --> Nb3N4 --> NbN when Nb was milled with N-2. However,

Ta₂N and an amorphous phase were formed when Ta was milled with N₂. The chemisorption of nitrogen onto the clean metal surfaces created by ball milling is believed to be the fundamental process governing solid-gas reactions, and the defects generated during MA can promote the diffusion of adsorbed nitrogen, and consequently the formation of metal nitrides. The difference in phase transition between the two systems is discussed.

[24] ON NITROGEN SORPTION DURING HIGH ENERGY MILLING OF SILICON POWDERS IN AMMONIA AND NITROGEN

Yang ZG. Ren RM. Xie XQ. Shaw LL. - Metallurgical & Materials Transactions A-Physical Metallurgy & Materials Science. 30(4):1109-1117, 1999

A systematic study on nitrogen sorption during high energy milling of Si powder in NH₃ and N₂ has been conducted. X-ray diffraction (XRD), transmission electron microscopy (TEM), and nuclear magnetic resonance (NMR) have been used to analyze the milled powder and correlate the enhanced nitrogen sorption to the structural change of Si powder during milling. It is found that the amount of the sorbed nitrogen in Si is substantially higher than that predicted by the equilibrium phase diagram. Further, the sorbed nitrogen is primarily present in the amorphous phase. NH₃ is found to be much more effective than N₂ in enhancing the sorption of nitrogen. Mechanisms responsible for these phenomena are discussed based on the structural change of Si powder and mechanical activation induced by high energy milling.

[23] SYNTHESIS, FORMATION AND CHARACTERISATION OF FeNbO₄ POWDERS

Ananta S. Brydson R. Thomas NW. - Journal of the European Ceramic Society. 19(4):489-496, 1999

A modified mixed oxide synthetic route has been developed for the synthesis of iron niobate, FeNbO₄ (FN). A rapid vibro-milling technique was employed, with the formation of FeNbO₄ phases investigated as a function of calcination temperature and dwell time by XRD and DTA. The particle size distribution of the calcined powder was determined by laser diffraction techniques, and the morphology, phase composition and crystal structure determined via SEM, TEM and EDX. It has been found that the unreacted Fe₂O₃ and FeNb₂O₆ phases tend to form together with FeNbO₄, with the latter appearing in both monoclinic and orthorhombic phases, depending on calcination conditions. It is seen that optimisation of calcination conditions can lead to a 100% yield of FeNbO₄ in an orthorhombic, alpha-PbO₂-type phase.

[22] MICROSTRUCTURAL EVOLUTION DURING COMBUSTION REACTION BETWEEN CUO AND AL INDUCED BY HIGH ENERGY BALL MILLING

Zhang DL. Richmond JJ. - Journal of Materials Science. 34(4):701-706, 1999

The product of the combustion reaction between CuO and Al induced by high energy ball milling has been characterised by using X-ray diffractometry and scanning electron microscopy. It has been observed that the combustion reaction can be ignited very easily by the ball milling. The reaction product consists of polycrystalline Cu in bulk and particle forms and a large number of nanometer sized spherical Al₂O₃ particles attached to the surface of the Cu. It has been demonstrated that this microstructure is evolved through rapid solidification of Cu and Al₂O₃ melts and rapid condensation of Cu vapour. Cu and Al₂O₃ phases are separated in the reaction product. The reason for this is mainly attributed to the large difference in their density and the shaking force of the ball mill.

[21] FORMATION OF METASTABLE PHASE EQUILIBRIUM AND AMORPHISATION IN AL₂₆ZR₇₄ ALLOY BY GAS ATOMIZATION AND BY FURTHER MECHANICAL ALLOYING

Savin VV. Chayka VA. Kostenko RV. - International Journal of Hydrogen Energy. 24(2-3):115-117, 1999

At the present day, the mechanical alloying of certain metallic components is actually a single method of obtaining a material with the required level of physical and chemical characteristics. Zr-Al system alloys are the perspective getter materials. The level of getter properties depends on the structural phase state of the produced specimens. The highly dispersive and amorphous materials have the highest level of getter properties.

[20] APPLICATION OF HYDROGEN VIBRATION MILLING IN THE PROCESSING OF NDFEB AND (ND,PR)FEB PERMANENT MAGNETS

Mottram RS. Yartys V. Guegan PW. Harris IR. - International Journal of Hydrogen Energy. 24(2-3):257-261, 1999

A Hydrogen Vibration Mill (HVM) was designed, constructed and then used to produce Nd-Fe-B powders. The powders were processed to give fully; dense, sintered magnets. When exposed to hydrogen, Nd-Fe-B material undergoes decrepitation, splitting bulk material into highly friable particles, suitable for milling. The supply of hydrogen to the mill was from a LaNi₅ store. The mill construction allowed in situ hydrogenation and milling at 0.5-5 bar H₂. This occurred in a stainless steel chamber of 1000 cm³ capacity with carbon chrome milling balls. The amplitude of vibration was 2-4 mm at 45 Hz. The in situ decrepitation and dry milling facilitated a low oxygen contamination, which is beneficial to sintering and magnetic properties. A milling time of 3 h yielded powders of 7 μm mean diameter, suitable for producing magnets. The best properties obtained were an energy product of 305 kJm⁻³, with coercivity of 704 kAm⁻¹.

[19] AL₂O₃/SiC NANOCOMPOSITES FROM ALTERNATIVE PROCESSING ROUTES

CE Borsa, RI Todd, RJ Brook - CERAMIC PROCESSING SCIENCE (Series: CERAMIC TRANSACTIONS), 1998, Vol 83, pp 101-108 - 6TH MEETING OF THE INTERNATIONAL CONFERENCE ON CERAMIC PROCESSING SCIENCE; SANTA BARBARA, CALIFORNIA. SEPTEMBER 7-10, 1997

This work investigated two alternative processing routes for the preparation Al₂O₃/SiC nanocomposites. One used a polymeric precursor for the SiC phase (polysilastyrene) and commercial alumina powder. The materials were mixed in toluene, dried and heated to 1500 degrees C to crystallize the SiC phase. The resultant powder consisted of SiC particles (50-300nm in size) distributed at the surface of the alumina particles. The second processing route utilized an inorganic precursor for alumina (aluminum nitrate). This precursor was dissolved in water in the presence of nano-sized commercial SiC and urea. Controlled heat treatments, at low and high temperatures, promoted the precipitation of an alumina phase onto the SiC particles. In both processing routes, the material was milled and hot pressed at 1700 degrees C to achieved full densification. TEM and XRD analysis were used to characterize the powders and the sintered pieces. Samples prepared from conventional mixture of commercial powders were used as

the control. It is shown that the use of chemical precursors produced distinctive microstructures, with different matrix grain sizes, SiC particle sizes and location in the matrix as compared to the control material.

[18] ENERGY DISSIPATION IN THE DYNAMICS OF A BOUNCING BALL

Szymanski K. Labaye Y. - Physical Review E. 59(3 Part A):2863-2871, 1999

A horizontally bouncing ball between a rigid wall and a sinusoidally vibrating plate is investigated analytically, numerically, and experimentally. Transient chaotic and chattering modes show substantially different shock power dissipation from that of resonant movement. Gain of the dissipated shock power is observed when the system enters into periodic modes. Period doubling routes to chaos have no substantial influence on the shock power. Connections of the proposed model with dynamics of mechanical alloying processes are discussed.

[17] TIME-DEPENDENT PARTICLE-SIZE DISTRIBUTIONS IN COMMINUTION

Zemskov EP. - Powder Technology. 102(1):71-74, 1999

Stochastic processes approach is used to describe grinding kinetics of granular materials. The time-dependent forms of normal and logarithmic-normal functions for grain-size distributions during comminution are considered. The properties of the fragment size distributions for main energy consumption laws (Kick, Rittinger and Bond laws) are discussed.

[16] SYNTHESIS AND CHARACTERIZATION OF NANOSTRUCTURED CR3C2-NICR

He J. Ice M. Lavernia EJ. - Nanostructured Materials. 10(8):1271-1283, 1998

Pre-alloyed Cr₃C₂-25 (Ni₂₀Cr) powder was synthesized by mechanical ball milling in Hexane [H₃C(CH₂)₄CH₃] and the variation of powder characteristics with milling time was investigated using SEM, X-ray and TEM. The average powder size drastically decreased with time during the first four hours of milling; then decreased slightly as milling continued up to 20 hours. For milling times in excess of four hours, the particle size approached 5 microns. X-ray diffraction analysis revealed a larger structural change in the NiCr solid solution powder relative to that experienced by the chromium carbide phases. This result indicated that the NiCr solid solution powder was subjected to heavier deformation than the chromium carbide powder. During the initial stages of milling, the brittle chromium carbide powders are fractured into sharp fragments and embedded into the NiCr solid solution powder. As milling continued a NiCr chromium carbide polycrystal composite powder was formed for times up to 20 hours of milling, transforming the sharp carbide fragments into spherical carbide particles. Conventional cold welding and fracturing processes primarily occurred only among the NiCr powder and composite powders. Milling times of up to 20 hours led to the formation of a polycrystal nanocomposite powder system in which chromium carbides, with average size of 15 nm, were uniformly distributed in NiCr matrix.

[15] CHARACTERIZATION OF SiCp/2024 ALUMINUM ALLOY COMPOSITES PREPARED BY MECHANICAL PROCESSING IN A LOW ENERGY BALL MILL

Angers R. Krishnadev MR. Tremblay R. Corriveau JF. Dube D. - Materials Science & Engineering A-Structural Materials Properties Microstructure & Processing. 262(1-2):9-15, 1999

In the present work, SiCp/2024 composite powders were produced by low energy ball milling a mixture of centrifugally atomized 2024 particles and beta-SiC reinforcements having a size range between 2 and 6 μ m. The experimental parameters studied were the milling time (between 1 and 24 h) and the volume proportion of beta-SiC in the starting powder mixture (between 5 and 35%). These SiCp/2024 composite powders were consolidated by hot extrusion using optimized processing parameters. The microstructure of the extruded composites showed a uniform distribution of beta-SiC particles in the 2024 aluminum matrix. Moreover, the mechanical properties (yield strength and Young's modulus) improved with the SiC content although some reduction in ductility was observed.

[14] THE BALL MILLING INDUCED TRANSFORMATION OF ALPHA-Fe₂O₃ POWDER IN AIR AND OXYGEN ATMOSPHERE

Zdujic M. Jovalekic C. Karanovic L. Mitric M. - Materials Science & Engineering A-Structural Materials Properties Microstructure & Processing. 262(1-2):204-213, 1999

The mechanochemical treatment of alpha-Fe₂O₃ powder was done concurrently in air and oxygen atmospheres using a conventional planetary ball mill. The influence of the duration of milling and of the balls-to-powder mass ratio on the transformation of alpha-Fe₂O₃ was investigated. Under appropriate milling conditions, alpha-Fe₂O₃ completely transforms to Fe₃O₄, and for prolonged milling to the Fe_{1-x}O_x phase, either in air or oxygen atmosphere. Owing to the higher oxygen pressure, the start of the reaction in oxygen is delayed by similar to 1 h in comparison with the reaction in air. The reverse mechanochemical reaction Fe_{1-x}O_x → Fe₃O₄, alpha-Fe₂O₃ takes place under proper oxygen atmosphere. The oxygen partial pressure is the critical parameter responsible for the mechanochemical reactions. The balls-to-powder mass ratio has a considerable influence on the kinetics of mechanochemical reactions. Below the threshold value the reaction does not proceed or proceeds very slowly. Plausibly, three phenomena govern mechanochemical reactions: (i) the generation of highly energetic and localized sites of a short lifetime at the moment of impact; (ii) the adsorption of oxygen at atomically clean surfaces created by particle fracture; and (iii) the change of activities of the constituent phases arising from a very distorted (nanocrystalline) structure.

[13] MECHANICALLY ACTIVATED SYNTHESIS STUDIED BY X-RAY DIFFRACTION IN THE Fe-AL SYSTEM

Charlot F. Gaffet E. Zeghmati B. Bernard F. Niepce JC. - Materials Science & Engineering A-Structural Materials Properties Microstructure & Processing. 262(1-2):279-288, 1999

The nanocrystalline phase formation in the Fe-Al binary system induced by a new low temperature process, called mechanically activated self-propagating high-temperature synthesis (MASHS), was investigated by X-ray diffraction (XRD) analysis. Some parameters of this alternative powder processing method which associates a short ball milling duration (leading to nanoscale 3-D polyinterfaces of the elemental components) and a self-propagating high-temperature synthesis (SHS) reaction, were studied. Their influence on the solid (liquid) state kinetic paths of phase formation was characterized. The XRD profile line analysis shows that it is possible to synthesize, for example, an FeAl intermetallic compound possessing a nanostructure (40 nm) using the MASHS process. Moreover, an infrared camera revealed that the mechanical activation step implemented before the SHS process decreases the ignition

temperature of the exothermic reaction (100 K) between pure Fe and Al, whatever the composition.

[12] ELECTRODE CHARACTERISTICS OF NANOSTRUCTURED Mg₂Ni-TYPE ALLOYS PREPARED BY MECHANICAL ALLOYING

Woo JH. Lee KS. - Journal of the Electrochemical Society. 146(3):819-823, 1999

A mechanical alloying process is introduced to produce nanocrystalline Mg₂Ni-type metal hydride. The mechanical alloying process has recently emerged as a novel technique for producing alloy powders whose structures are nanocrystalline. Mg₂Ni alloys were prepared using planetary ball mill starting from mixtures of elemental powders. Nanocrystalline Mg₂Ni-type alloys were obtained by both the long-term ballmilling (mechanical alloying) and heat-treatment of the ballmilled powders. In comparison with the polycrystalline material, nanocrystalline Mg₂Ni showed a lower temperature for hydrogenation and a higher discharge capacity at 30 degrees C. The partial substitution of Cu for Ni increased hydrogen absorption and desorption at 200 degrees C and greatly improved the discharge capacity of the nanostructured Mg₂Ni electrode at 30 degrees C. The discharge capacity of the 120 h milled Mg-2(Ni_{0.9}Cu_{0.1}) electrode was 350 mAh/g.

[11] PROCESSING OF COMPOSITE AL/SiC POWDERS FOR PLASMA SPRAYING

Ghosh K. Troczynski T. Chaklader AC. - International Journal of Powder Metallurgy. 35(2):27-35, 1999

The use of aluminum in automobile engine blocks and other critical parts such as cam rods and valves requires superior surface properties. This has led to the development of thermally sprayed surface coatings for this type of component. To impart maximum bond strength, and superior wear resistance, a plasma sprayed aluminum based composite (Al-SiC) was found to be more suitable than current metallic or ceramic coatings. To eliminate inhomogeneities arising from blended powders, composite powders were prepared by mechanical alloying of 6061 Al alloy with SiC particles. The concentration of SiC was varied between 20 and 75v/o. The size of the reinforcement was varied from 8 to 37 μ m in the Al-50v/o SiC composites. An organic process control agent was used to modify the morphology of the powders during mechanical alloying. The 44 to 140 μ m powders were sprayed using an axial feed plasma torch. Adhesion strength, hardness, abrasive and erosive wear resistance of the coatings were assessed.

[10] DEFORMATION-ASSISTED DECOMPOSITION OF UNSTABLE Fe₅₀Cu₅₀ SOLID SOLUTION DURING LOW-ENERGY BALL MILLING

Xu J. Collins GS. Peng LSJ. Atzmon M. - Acta Materialia. 47(4):1241-1253, 1999

An unstable, f.c.c. Fe₅₀Cu₅₀ solid solution was prepared using high-energy ball milling of an elemental powder mixture. It was used as a parent alloy for isothermal annealing or low-energy ball milling (LEBM), both at 373-523 K. Alloy evolution was analyzed by X-ray diffraction, Mossbauer spectroscopy and differential scanning calorimetry. LEBM significantly enhanced the initial decomposition rate, but the decomposition process was complex and not monotonic. At and below 423 K, the initial decomposition was completely reversed at later times. The results are interpreted in terms of an effective-temperature model proposed by Martin for irradiated alloys. A dynamic phase diagram in the effective temperature is presented, and used to explain the presence of a two-phase region under all milling conditions. The nonmonotonic behavior is suggested to be a result of coupling between phase evolution and mechanical properties, leading to a time dependence of the effective temperature.

[9] KINETICS OF MICROSTRUCTURE EVOLUTION IN NANOCRYSTALLINE FE POWDER DURING MECHANICAL ATTRITION

Tian HH. Atzmon M. - Acta Materialia. 47(4):1255-1261, 1999

The microstructure evolution in Fe powder during ball milling at different temperatures and intensities is investigated. Steady-state grain sizes below 12 nm are obtained, which increase weakly with decreasing milling intensity or increasing temperature. A phenomenological model is proposed, based on the assumption of simultaneous grain refinement and grain growth. This model fits well all data sets. The weak temperature dependence of the grain-growth term is consistent with nonequilibrium vacancy production. The fit results indicate that the efficiency for refinement and vacancy production decreases with increasing vibration amplitude.

[8] INTERFACE-DRIVEN ALLOYING AND METALLIC GLASS FORMATION IN NANO-MULTILAYERS IN AN IMMISCIBLE Y-Nb SYSTEM

Chen YG. Liu BX. - Acta Materialia. 47(4):1389-1397, 1999

Several new amorphous alloys were obtained in an immiscible Y-Nb system by room temperature 190 keV xenon ion mixing of Y-Nb multilayered films, which were designed to include a sufficient fraction of interfacial atoms and thus possessed a high free energy comparable to that of the amorphous state. In addition, two metastable f.c.c. phases were formed in Y-rich and Nb-rich multilayered films, respectively. The growth kinetics of the f.c.c. phases and their effect on the composition range of amorphization are also discussed. To understand the observed unusual alloying behaviors, a Gibbs free-energy diagram was constructed based on Miedema's model. The diagram included the free-energy curves of all the involved phases as well as that of the Y-Nb multilayered films including the extra interfacial free energy and thus gave a qualitative and reasonable interpretation to the formation of metastable alloys upon ion mixing; Furthermore, some multilayered films with a sufficient fraction of interfacial atoms were subjected to steady-state thermal annealing, which also resulted in the formation of the Y-Nb amorphous phases, suggesting that alloying in this immiscible system was actually driven by the interfacial free energy.

[7] ATTRITION GRINDING AND LEACHING OF ENARGITE CONCENTRATE

Balaz P. Achimovicova M. Sanchez M. Kammel R. - Metall. 53(1-2):53-56, 1999

Enargite Cu₃As₄S₄ belongs to minerals with very low hydrometallurgical extractibility of copper. AN application pretreatment of enargite concentrate in acid solutions leads to simultaneous dissolution of copper and arsenic and the final leach liquors solutions have to be treated for the separation of both elements. The application of alkaline sodium sulphide solutions favours a selective leaching of arsenic and the copper forms solid residues suitable for pyrometallurgical treatment. The experiments have shown that more than 90% of arsenic can be extracted from enargite by atmospheric alkaline leaching at 90 degrees C. An applied mechanical activation enhances the rate of

arsenic extraction.

[6] MECHANOCHEMICAL SYNTHESIS OF 0.9 PB(MG1/3NB2/3)O-3-0.1PB(TIO)3 FROM MIXED OXIDES

Wang J. Wan DM. Xue JM. Ng WB. - *Advanced Materials*. 11(3):210+, 1999

Electrostrictive actuators and multilayer capacitors are two potential applications for PMN-PT (the title compound). Its preparation by mechanochemical reaction at room temperature as an ultrafine nanocrystalline powder of perovskite structure is reported here. The Figure shows a scanning electron micrograph of the fracture surface of PMN-PT following sintering at 1050 degrees C for 1 h.

[5] THERMAL DECOMPOSITION OF MECHANICALLY ACTIVATED GIBBSITE

MacKenzie KJD. Temuujin J. Okada K. - *Thermochimica Acta*. 327(1-2):103-108, 1999

Gibbsite (Al(OH)₃) was mechanically activated by grinding for 20 h, and the changes in its structure were studied by thermal analysis, X-ray powder diffraction and Al-27 MAS NMR. Grinding caused the rupture of a significant proportion of the Al-OH bonds, but the resulting molecular water was immediately adsorbed on to the activated surfaces from which it could be endothermically desorbed at 125 degrees C. Grinding causes the gibbsite to become X-ray amorphous, containing octahedral and tetrahedral sites, and another site at about 34 ppm sometimes ascribed to Al in 5-fold coordination; the relative site occupancies suggest that this phase is similar to rho-Al₂O₃. The amorphous phase converts via gamma-Al₂O₃ to alpha-Al₂O₃ (corundum) at 900 degrees C, by contrast with unactivated gibbsite which transforms to corundum via gamma and theta-Al₂O₃ at least 400 degrees C higher

[4] MECHANOCHEMICAL SYNTHESIS AND CHARACTERIZATION OF POLY(VINYL CHLORIDE)-BLOCK-POLY(VINYL ALCOHOL) COPOLYMERS BY ULTRASONIC IRRADIATION

Fujiwara H. Ishida T. Taniguchi N. Wada S. - *Polymer Bulletin*. 42(2):197-204, 1999

Mechanical degradation and mechanochemical reaction in heterogeneous systems of the solid poly(vinyl chloride)-poly(vinyl alcohol) aqueous solutions have been studied by ultrasonic irradiation at 30 degrees C. The rate of decrease in the viscosity-average degree of polymerization of the degraded poly(vinyl chloride) was much faster than that of the degraded poly(vinyl alcohol). Mechanochemical reaction occurred by free radicals produced from the chain scissions of both polymers by ultrasonic waves. The copolymer was obtained and the molar ratio of the vinyl chloride and the vinyl alcohol units in its copolymer can be determined. In addition, the changes in the composition of the total block copolymer, the unreacted poly(vinyl chloride), and the unreacted poly(vinyl alcohol) were obtained.

[3] MOSI₂-ZRO₂ COMPOSITES-FABRICATION, MICROSTRUCTURES AND PROPERTIES

Yi DQ. Li CH. - *Materials Science & Engineering A-Structural Materials Properties Microstructure & Processing*. 261(1-2):89-98, 1999

In this study, dense monolithic MoSi₂ and MoSi₂-ZrO₂ composites were fabricated by hot-pressing from mechanically alloyed (MA) and commercial MoSi₂ powders, unstabilized zirconia (UZ) and yttria partially stabilized zirconia (YPSZ) powders. The microstructures and properties of these materials were characterized. Hot-pressed monolithic materials and composites were consolidated to 96.1-99.5% density. Zirconia phases identified in the composites MoSi₂-UZ and MoSi₂-YPSZ were monoclinic and tetragonal, respectively. The MA-MoSi₂ powder prepared materials have a higher hardness due to the refinement of the matrix. The toughness of the composites UZ and YPSZ were 2.4 times and 20% higher than that of MoSi₂. The predominating fracture modes have been identified. High density of microcracks and dislocations were observed in UZ composites but not in YPSZ composites. Microcracking is suggested to be the main toughening mechanism for the former; while for the latter, the improvement in toughness could be attributed, at least partly, to crack deflection.

[3] AN OVERVIEW OF POWDER PROCESSING OF SILICIDES AND THEIR COMPOSITES

Stoloff NS. - *Materials Science & Engineering A-Structural Materials Properties Microstructure & Processing*. 261(1-2):169-180, 1999

The use of powders to prepare fully dense silicides and their composites is reviewed. Since most of the techniques are well known, we concentrate on recent developments in this field; including the effects of processing techniques on composition, microstructure and mechanical properties. The use of hybrid processes to produce silicides is described, as are hybrid materials resulting from these processes. Included in the latter are functionally graded materials (FGM). The paper concludes with a brief discussion of in-situ melt processing as a competitive means to produce aligned composite structures

[2] THE INFLUENCE OF STABILIZERS ON MECHANOCHEMICAL PROCESSES IN SBR RUBBERS

Ristic R. Vrhovac L. Plavsic M. - *Journal of Applied Polymer Science*. 72(6):835-847, 1999

Mechanochemical processes in commercial and model SBR rubbers containing different stabilizers were investigated. The influence of chemical structure and concentration of stabilizers in the temperature range from 20-170 degrees C and in the presence of air, i.e., under conditions similar to that in industrial processes, were studied. Stabilizers used were diaryl-p-phenylene-diamine, alkyl-aryl-p-phenylene diamine, polynuclear phenol, aryl-alkyl phenol, and alkyl-alkyl phenol. It was found that mechanochemical processes in SBR rubbers are less developed in the temperature region from 70-130 degrees C, so the influence of stabilizer is less expressive. During increasing temperature (130-170 degrees C) structure and concentration of stabilizers both show a strong influence on type and intensity of mechanochemical processes in SBR rubbers: p-phenylene-diamines favor processes of linear degradation, while phenol stabilizers direct them toward branching and crosslinking, which is more expressed in the presence of aryl-substituted phenols than alkyl-substituted phenols. This fact is based on the differences in stability of free stable radicals of p-phenylene-diamines, alkyl-substituted phenols and aryl-substituted phenols. The fact that phenol stabilizers are involved in chain degradation as well as in branching and crosslinking processes during rubber processing, can be of high practical importance;

[1] MECHANOCHEMICAL SYNTHESIS OF 0.9 PB(MG1/3NB2/3)O-3-0.1PB(TIO)3 FROM MIXED OXIDES

Wang J. Wan DM. Xue JM. Ng WB. - *Advanced Materials*. 11(3):210+, 1999

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