



CMAN -2020 Virtual Event

**Online Summit on Carbon
Materials and Nanotechnology**

JUNE 30-JULY 01, 2020



Book of Abstracts

A rectangular area with a background image of a porous, interconnected carbon structure, likely a porous carbon material or a carbon nanotube network. The structure is shown in grayscale, with a complex, honeycomb-like pattern of interconnected nodes and lines. The text "Book of Abstracts" is overlaid in the center in a large, bold, white font.

A central rectangular area with a dark, textured background showing a complex, interconnected network of light-colored, fibrous or cellular structures, resembling a microscopic view of a porous material or a biological network. The text "Plenary Presentations" is centered over this area in a large, white, sans-serif font.

Plenary Presentations

Online Summit on Carbon Materials and Nanotechnology

JUNE 30-JULY 01, 2020

Development of Superconducting Super-magnets for Day to Life Applications

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Abstract

In 21st century, the global community is facing a problem of possible future of running out of oil parallel with increase of energy consumption in connection with expected population growth to 8-10 billion people to the year of 2050. Recent analysis and technological developments clarified that we are emitting twice the amount of CO₂ that atmosphere can integrate; as a result, many people worry about their future. For eradicating this issue, varied alternate energy sources: solar, wind, high- T_c superconductivity may be crucial. For instance, the electricity generation by photovoltaics (PV) is needed to highly expand over present scale of Gigawatts. In connection with this goal, development of energy storage and transportation technologies will be necessary. Together with solving the energy production and transport issues, the development of new materials along with innovative technologies saving energy consumption is beneficial. In this talk, recent trends in high- T_c superconducting material processing will be introduced and then new super-magnet applications will be presented. The bulk high- T_c superconducting magnets can trap magnetic fields by order of a magnitude higher than the *best classical hard magnets* and are promising as permanent magnets for its use in several industrial applications including in medical field. Superconducting material is also used in superconducting DC cables, promising in particular in transport of solar energy as well as in feeding cables for railway system applications. In this invited talk, I will summarize recent developmental use of bulk superconducting materials in superconducting magnets and that of superconducting cables within various industrial applications.

Biography

He is the Deputy President and Board of Councilor at Shibaura Institute of Technology (SIT) and Professor at the Graduate School of Science and Engineering. His main task is to transform SIT into a high rank university. Interested in applications and technology of bulk single-grain superconductors; thus, I had developed a new class of mixed LRE-123 system which can be used up to 15 T at 77 K and high temperatures up to 90.2 K. I also developed a novel technology to produce a RE-123 type silver sheathed wire on the basis of solid state / liquid phase reaction. My intellectual mindset enabled me to produce a small type superconducting bulk magnet which is useful to magnetize both high- T_c superconducting materials and magnetic materials in a variety of industrial applications. Further, I also contributed to develop technology for the development of DC Superconducting Cable for Railway system applications. I am an author and co-author for more than 420 publications in international journals and delivered over 110 oral presentations including plenary and invited ones. I hold several Japanese national and international patents. Awards: Young Scientist Project Award, DST-Govt. of India (1995), Director's Award, SRL-ISTEC (1998 and 2003), 1999 PASREG Award of Excellence (1999), Best Presentation Award at the IWCC11 (2003), Best Researcher Award, ISTEC-SRL (2007 and 2008), Best Researcher Award, Railway Technical Research Institute (2012), the Amity Global Academic Excellence Award (2017), Engineering Education Award for Contribution in Higher Education (2018), SIT Excellent Education Award (2019). I am an Editor-in-Chief and Editorial board member of several international journals.

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Interfacial Modification in Nanocomposites to Tailor Functionalities

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Abstract

The talk will concentrate on various approaches being used to engineer materials at the nanoscale for various applications in future technologies. In particular, the case of clay, carbon nanostructures (e.g. nanotubes, graphene), metal oxides, bionanomaterials (cellulose, starch and chitin) will be used to highlight the challenges and progress. Several polymer systems will be considered such as rubbers, thermoplastics, thermosets and their blends for the fabrication of functional polymer nanocomposites. The interfacial activity of nanomaterials in compatibilising binary polymer blends will also be discussed. Various self assembled architectures of hybrid nanostructures can be made using relatively simple processes. Some of these structures offer excellent opportunity to probe novel nanoscale behavior and can impart unusual macroscopic end properties. I will talk about various applications of these materials, taking into account their multifunctional properties. Some of the promising applications of clay, metal oxides, nano cellulose, chitin, carbon nanomaterials and their hybrids will be reviewed. Finally the effect of dewetting up on solvent rinsing on nano scale thin films will also be discussed.

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S. Thomas et al. *Journal of Materials Chemistry C*, 2014. 2(40), 8446-8485

Biography

Current Position: Vice Chancellor of Mahatma Gandhi University and the Founder Director and Professor of the International and Interuniversity Centre for Nanoscience and Nanotechnology. He is also a full professor of Polymer Science and Engineering at the School of Chemical Sciences of Mahatma Gandhi University, Kottayam, Kerala, India.

Areas of Research: Nanoscience, Polymer Science and Engineering, Polymer Nanocomposites, Elastomers, Polymer Blends, Interpenetrating Polymer Networks, Polymer Membranes, Green Composites and Nanocomposites, Nanomedicine and Green Nanotechnology.

Major Contributions: Inventions in polymer nanocomposites, polymer blends, green bionanotechnological and nano-biomedical sciences, have made transformative differences in the development of new materials for automotive, space, housing and biomedical fields. In collaboration with India's premier tyre company, Apollo Tyres, Professor Thomas's group invented new high performance barrier rubber nanocomposite membranes for inner tubes and inner liners for tyres.

Honorary Doctorate (Honoris Causa) : conferred *Honoris Causa (D.Sc) Doctorate by the University of South Brittany, Lorient, France and University of Lorraine, Nancy, France.*

Publications: Professor Thomas has published over 1000 peer reviewed research papers, reviews and book chapters.

Books: Co-edited 127 books published by Royal Society, Wiley, Wood head, Elsevier, CRC Press, Springer, and Nova etc.

Patents: Filed 16 patents, one has been granted

H index: 97 (H Index indicates the quality and quantity of publications of a faculty), highest in Kerala 5th in India in Engineering Sciences

Citations: More than 43,000 citations.

Plenary/Inaugural and Invited lectures: Delivered over 300 Plenary/Inaugural and Invited lectures in national/international meetings over 30 countries.

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(Oral & Invited)

Green & Sustainable Fabrication of Organic Solar Cells

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Abstract

Background/ Objectives and Goals

Unlike conventional silicon-based photovoltaic technology, organic solar cells (OSCs) can be prepared as semi-transparent or flexible devices and thus display a great potential as next-generation integrated renewable energy technology. However, in addition to the relatively short lifetime of OSCs, conventional OSC fabrication results in a large amount of costly materials and hazardous solvent wastes. The objective of our research is to find innovative green & sustainable solutions for the fabrication or recycling of efficient OSCs.

Methods

Here, we present two methods to considerably reduce the amount of wasted materials generated during the OSC fabrication or when discarding degraded OSCs.

Method 1: Push-coating of thin active layers

OSC active layers are conventionally fabricated using spin-coating, a deposition technique expels large amounts of costly material and hazardous solvent released in the environment. We developed the push-coating method (Figure 1), in which uniform thin films are produced by spreading small volumes of organic semi-conductor solutions between the substrate and a stamp through capillary forces. This fabrication process does not generate any active material waste and minimizes the use of hazardous solvents. We verified whether push-coating can be applied to OSC fabrication with several state-of-the-art active materials.

Method 2: Recycling of transparent electrode substrates from degraded OSCs

The short life-time of OSCs can be associated with their active layer oxidation (Figure 2). Despite the durability of zinc oxide (ZnO) coated indium tin oxide (ITO) transparent cathode substrates, these costly substrates are discarded when OSCs reach the end of their lifetime. Here, we optimize the recycling of ITO/ZnO substrates and verify if they can be reused for the fabrication of efficient OSCs.

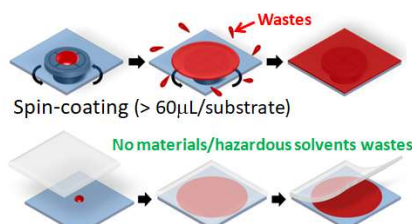


Figure 1: schematic representations of the spin-coating and push-coating processes

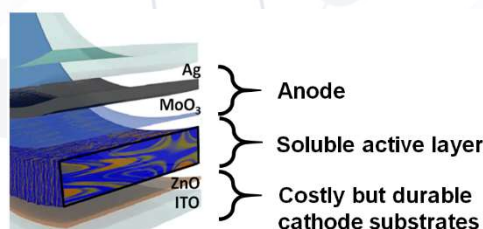


Figure 1: OSC device architecture

Expected Results/ Conclusion/ Contribution

Our results clearly demonstrate that push-coating is a versatile technique that yields power conversion efficiencies (PCEs) on par with those of spin-coated OSCs (Table 1). We are currently investigating non-fullerene active layers to potentially produce push-coated OSCs with PCEs above 10%. Additionally, we demonstrated that surface cleaning of recycled ITO/ZnO is a necessary step to produce devices with similar PCEs as reference OSCs prepared on unused ITO/ZnO. Multiple recycling of the same substrate without drops in performances can be carried out by avoiding the use of isopropanol (IPA) which damages the ZnO layer (Table 2).

method	active materials	PCE
spin	P3HT:PC ₆₁ BM	3.30%
push	P3HT:PC ₆₁ BM	3.34%
spin	PCDTBT:PC ₇₁ BM	5.77%
push	PCDTBT:PC ₇₁ BM	5.77%

Table 1: spin-coated and push-coated OSCs.

ITO/ZnO recycling	PCE
0 time	8.73%
w/o IPA (1 time)	8.66%
w/o IPA (10 times)	7.93%
w/IPA (1 time)	8.65%
w/IPA (10 times)	5.14%

Table 2: recycled OSCs.

Keywords: Organic Solar Cells; Substrate recycling; Waste reduction; Environment-friendly

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Biography

Varun Vohra is a French researcher who completed his PhD in Materials Science from the University of Milan-Bicocca in 2009 at the age of 25. He was a EU Marie-Curie Fellow (2006~2009) and a JSPS Post-doctoral Fellow (2011~2014) before joining the University of Electro-Communications (UEC) in 2014. He established his research group focusing on organic solar cells (OSCs) at UEC, where he obtained tenure as Associate Professor in 2019. He pioneered in fabricating OSCs with efficiencies over 10% and has authored over 40 academic publications including papers on prestigious journals such as *Nature Photonics*.

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Application of Poly(tetrafluoroethylene) as a Support for Metal Nanoparticles

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Abstract

One major drawback of metal nanoparticles as a catalyst is that the catalytic activity tends to lose during use because of the formation of aggregates via so-called Ostwald ripening. Our group successfully have developed linear polystyrene-stabilized metal nanoparticles with high recyclability for several reactions in water. Linear polystyrene-stabilized metal nanoparticles, however, could not be used for the reaction including C-H activation of aromatic ring and hydrogenation of aromatic ring. Therefore, we chose poly(tetrafluoroethylene) (PTFE) as a new support.

PTFE-stabilized Pd nanoparticles (PTFE-PdNPs) were prepared in water and characterized using powder X-ray diffraction (XRD), transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), and inductively coupled plasma-atomic emission spectroscopy (ICP-AES). Small Pd nanoparticles with a fairly uniform size were obtained in the presence of PTFE, whereas aggregation of palladium was observed in the absence of PTFE. PTFE-PdNPs showed high catalytic activity for the Suzuki coupling reaction in water and were reused without any loss of activity. No palladium species were observed by ICP-AES analysis in the reaction solution after the reaction, nor was any change in particle size observed after the recycle experiment. PTFE was also useful as the stabilizer of RhNPs. PTFE-RhNPs showed high catalytic activity and reusability toward arene hydrogenation under mild conditions.

Keywords: Poly(tetrafluoroethylene); Metal nanoparticles; Hydrogenation, Water

Biography

Atsushi Ohtaka received a Ph.D. from Osaka University in 2003 under the direction of Professor Hideo Kurosawa. He then worked for two years as a post doctor research fellow in National Cardiovascular Center, for a year in Institute for Molecular Science under the direction of Professor Yasuhiro Uozumi, and for a period of half year as a visiting researcher in Alicante University under the direction of Professor Carmen Nájera. He became an assistant professor (2006) and associate professor (2013) at Osaka Institute of Technology where he won an award for encouragement of Research in Materials Science in 2008.

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Sensitive Thin-film Magneto-Impedance Sensor System Used in Strong Normal Magnetic Field for Detecting Small Particles

Tomoo Nakai

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Abstract

Background/ Objectives and Goals

Detection of foreign matters and nanoparticles included in industrial and chemical products is an important application target for a sensor system. A recent improvement of manufacturing system desired strongly an inspection of all items in every production process for realizing the smart manufacturing system. Therefore it is desired to detect such particles included in the products nondestructively. A thin-film magnetic field sensor provides an impressive candidate for this target, since it has an extremely high sensitivity, and it also has tolerance of normal magnetic field due to its demagnetizing force in the thickness direction. In this study, a sensitive sensor system which is used with applying a strong normal field for the purpose of evaluating a magnetic property of small particles included in industrial and chemical products.

Methods

Our previous work of sensor driving circuit provided an impressive candidate for realizing this target (1). It proposed a sensor system using the combination of a chip Voltage Controlled Oscillator (VCO), a Magneto-Impedance (MI) sensor, and a logarithmic amplifier. In this study, the sensitivity of sensor system with applying 0.3 T normal field was evaluated using the previously proposed 400 MHz driven thin-film magneto-impedance sensor system. The measurement was carried out using Kerr microscope (BH-762PI-MAE, NEOARK CORPORATION, JAPAN). The evaluation of sensitivity and also an observation of magnetic domain with applying 0.3 T normal field was done by this apparatus. The apparatus was composed of the Kerr microscope system with a 0.5 T electromagnet in the polar-direction. A coil for generating a horizontal X-direction magnetic field, and the thin-film magneto-impedance sensor system was set between a pair of vertical pole pieces of the polar-electromagnet. The optical focusing point of the Kerr microscope is made to be a just middle and center of the pole piece of the vertical magnet where a uniform normal field was constructed. Our measurement was carried out using this point of uniform and strong magnetic field.

Expected Results/ Conclusion/ Contribution

The sensitivity of a sensor system which was made with combination of applying 0.3 T normal field and also of using 400 MHz high-frequency driven thin-film magneto-impedance sensor was evaluated. The value of 0.3 T magnetic field would expect to make a magnetic nanoparticle particle to almost saturation magnetization. The result shows that our sensor system can detect 5×10^{-8} T of 5 Hz alternating magnetic field within 0.3 T normal field. An observation of the magnetic domain was also carried out while driving by 400 MHz within 0.3 T normal magnetic field, which resulted in the variation of magnetic domain was qualitatively the same as the one in the zero normal field. The main effect of the strong normal field to the thin film MI sensor property is both the reduction of variation range and the reduction of the effective sensitivity of the impedance variation. The sensitivity reduced to 59% when the normal field $B_z = 0.3$ T.

Keywords: Magneto-impedance sensor; Thin-film, High frequency; Logarithmic amplifier; Nondestructive inspection

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Biography

Tomoo Nakai received a Ph.D degree in electrical engineering from Tohoku University in 2005, and presently a general researcher of electrical and information technology department of Industrial Technology Institute, Miyagi Prefectural Government. He has worked on magnetic sensor, sensor network, energy harvesting, and electromagnetic compatibility (EMC) technology. The Magnetic Society of Japan, The Japanese Society of Mechanical Engineers, The Japanese Society of Non-Destructive Inspection, and IEEE member.

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Recovery and Reuse of the Catalyst in Cross-Coupling Reactions at ppm Molar

Catalyst Loading

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Abstract

Background/ Objectives and Goals

Despite Pd-catalyzed reactions are very useful in organic synthesis, Pd as a catalyst has two main drawbacks. One is the cost of Pd, which is a problem especially in the industrial field. The other is the toxicity of Pd leads to problems in contamination of the final product. To solve these problems, several catalytic systems with catalyst loading at mol ppm levels or less have been developed. However, recovery and reuse of catalysts have not been achieved in these systems because the loading of catalyst is very low.

Some examples have been described that metal species exist on the surface of stirring bar used for catalytic reaction even after conventional cleaning. We found metal nanoparticles supported on hydrophobic polymers can reuse without loss of activity in catalytic reactions in water. Based on these findings, we considered stirring bar can be used as a support of metal nanoparticles in water. The loading of Pd on the surface of stirring bar was investigated by inductively coupled plasma-optical emission spectroscopy (ICP-OES). When the Suzuki coupling reaction of bromobenzene with 4-methylphenylboronic acid was performed with used stirring bar (less than 100 mol ppm Pd) in KOH aqueous solution, corresponding coupling product was obtained and the stirring bar was reused several times. On the contrary, no reaction took place in organic solvent with the same stirring bar.

Keywords: Stirring bar; Suzuki coupling reaction; Pd; water

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Magnetization of Carbonaceous Particles with Reduced Size Detected in a Short Microgravity Condition

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Abstract

Background/ Objectives and Goals

In principle, experimental values of diamagnetic susceptibility χ_{dia} and its anisotropy $\Delta\chi_{\text{dia}}$ of a single particle can be used to estimate the extent of structural deformation from a bulk crystal. This is possible because they originate from the spatial distribution of localized electron of individual particles. However, using the conventional methods, the lower limit of measurable size in detecting χ_{dia} and $\Delta\chi_{\text{dia}}$ are at the level of $\sim 1\text{mm}$ in diameter.

Methods

It is presently considered that magnetizations of a single nanometer-size sample are difficult to measure. Note that the exact value of mass m of sample, which is necessary in determining χ_{dia} and $\Delta\chi_{\text{dia}}$, is difficult to obtain. Hence, as a first step to realize this task, translation of sub-mm size particles induced by magnetic field gradient were observed in a short microgravity condition (duration $< 0.5\text{ s}$) [1][2]. Specifically, graphite, diamond as well as major organic particles translated in a direction in which the field intensity monotonically decreased; the field distribution was produced by a pair of small niobium magnetic plates, and the particles are released in a microgravity area during the experiment. Carbonaceous materials are diamagnetic, and has not been considered to cause dynamic motion at a low field intensity below 1 Tesla.

Expected Results/ Conclusion/ Contribution

It was confirmed from the above observations that acceleration of the field-induced translation was proportional to intrinsic χ_{dia} value assigned to the material of the particle and was independent to m . Hence principle of detecting χ_{dia} of a single nano-size particle from its field-induced translation is experimentally confirmed [2]; note the value of m is unnecessary, and χ_{dia} can be determined if translation of a single particle is observable. Furthermore, $\Delta\chi_{\text{dia}}$ was obtained without measuring m by measuring the period of rotational oscillation with respect to magnetic field [2]. Based on the above results, the technical problems in reducing the measurable sample size is discussed. The motions reported in the present study is observed in all categories of magnetic materials, i.e., in paramagnetic [2] and in ferromagnetic particles [3]. In future, the technique may extend as a tool of pre-treatment in separating and analysing ensemble of small particles with different sizes at normal gravity condition [4].

Keywords: Diamagnetic susceptibility; Diamagnetic anisotropy; Microgravity; Field-induced dynamic motion

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Biography

Dr. Uyeda completed his doctorate in physics with high magnetic-field research on solid & liquid oxygen at Osaka University in 1985. He worked on in-situ isotope mapping of primitive meteorites at College of General Education, Osaka University as an assistant professor (1985-1992). He proposed a "chemical bonding model" to explain the origin of $\Delta\chi_{\text{dia}}$ during his research period at PRESTO, JST (1996~1999). Presently he is a member of the Institute of Earth & Space Science, Osaka University. His research subject is to prove the efficiency of motions in existing solid induced by low field intensities in nature.

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Spark Plasma Sintering: Densification of Functional Materials

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Abstract

The non conventional Spark Plasma Sintering (SPS) is based on the combination of high current and mechanical pressure directly applied to the powder material. This process offers several advantages:

1) grain growth control

2) possibility to obtain a dense material with a short processing time at a lower temperature (down to the 200°C range) than the conventional sintering and /or hot pressing techniques. Different works have been reported since the introduction of the first SPS machines in laboratories. Although many teams have tried to understand the densification mechanisms involved there is no consensus on this issue.

After a brief history of the SPS technique, an overview of this process will be exposed. In a second part, the grain growth control, the densification process as well as the functional properties will be discussed for: (i) Superconductive MgB₂ cryo-magnets and (ii) recycled NdFeB permanent magnets.

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Controlling Factors on Flux Trapping and Flux Jump in Pulsed-Field Magnetizing for Mg-B Bulk Magnet

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Abstract

Background/ Objectives and Goals

MgB₂ bulk materials are characterized as its uniform field trapping property originated from homogeneous microstructure of simple metallic compound. Although its T_c is low as 39 K, the microstructural uniformity brings its beautiful conical trapped field distribution when activated by magnetic field of outside. The authors have tried to overcome the crucial drawback of the thermal instability to obtain high field trappings in MgB₂ bulk magnets.

Methods

The experimental procedures were carried out in a couple of ways. One was to approach from material processing, and the other was how to let the magnet trap the flux. The authors attempted the metallic Ti-addition to improve the thermal properties. The samples were fabricated by *in-situ* process using hot-press sintering. As for the magnetic activation, the authors employed the pulsed-field magnetizing (PFM) with a rise time of 10 ms at 15 K with use of a two-stage GM-cryocooler. To estimate the flux motion during the PFM process, the parameters were defined as the field penetration ratio B_p/B_A and field trapping ratio B_T/B_p, where B_A and B_p correspond to the highest peak of applied fields and flux penetrations, respectively. B_T means the final trapped field at the end of time-evolutional profiles.

Expected Results/ Conclusion/ Contribution

The hot-pressed MgB₂ samples were identified by XRD, as shown in Fig. 1. The samples were prepared by the students studying abroad from Niigata University with heartfelt assistance of professors and researchers of IFW Dresden. The pellets mainly consist of MgB₂ with less inclusions of MgO and pre-reacted Mg. In the conference, the microstructural consideration will be discussed in detail. The improvement of J_c was discussed as functions of applied fields and temperatures in Fig. 2. The addition of Ti elevated the J_c values in every temperature region.

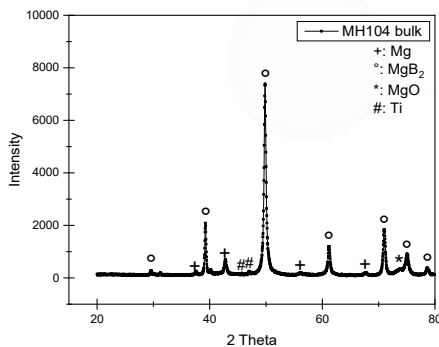


Figure 1 XRD for Ti-2.5 Wt%-doped MgB₂

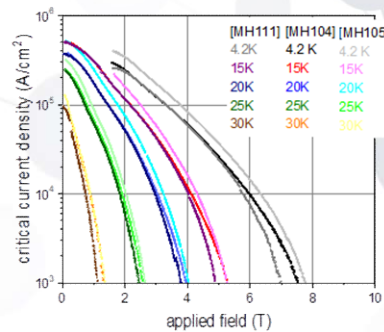
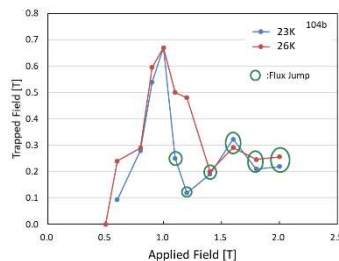


Figure 2. J_c of various Ti addition samples

The trapped flux B_T reached the highest peak of 0.67 T at 1.0 T application, as shown in Figure. 3 below (Figure 3. Trapped-field performances with various temperature)



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The sudden dissipations of trapped flux called as “flux jump” occurred due to the poor specific heat of the material in low temperature region. This means that the effect of J_c enhancement is less important than the heat capacity of the sample. The PFM experiments were successively carried on, and various flux jump phenomena were carefully observed in detail. The flux motions were classified as three categories called “no flux flow (NFF)”, “fast flux flow (FFF)”, and “flux jump (FJ)” regions. Ti-addition was found to be effective to expand the NFF region to high applied field and to prevent the flux jump to happen.

Keywords: Superconductor; Magnesium diboride; Pulsed field; Magnetic property; Flux jump

Biography

Professor Tetsuo OKA Dr. Eng. graduated from Kyoto University in 1979 in Japan, obtained his Ph. D from Nagoya University in 1992. His majors are metallurgy, magnetism, materials science and their practical applications to superconducting devices. After working for Niigata University, he now belongs to Shibaura Institute of Technology from 2018. A member of IEEE, Cryogenics, Metallurgy, Mechanical Engineering Associations.

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Co-addition of Dy₂O₃ and La₂O₃ Rare Earth oxides for Enhancing Critical Current Density of MgB₂

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Abstract

In this study, polycrystalline samples with nominal composition of MgB₂ were synthesized through *in situ* reaction method. In particular, carbon-encapsulated boron powder (1.35 wt.% carbon) together with magnesium powder was used for preparing the samples. Different weight percentages of rare earth oxides of Dy₂O₃ and La₂O₃ according to the ratio of x wt.% Dy₂O₃: x wt.% La₂O₃ ($x = 0.00, 0.25, 0.50, 0.75, 1.00$) were used as additives. By increasing the amount of the additives, critical temperature, T_c of the samples was only reduced slightly from 38.1 K to 37.6 K. However, critical current density, J_c was increased greatly. At 20 K, the highest self-field J_c of 433 kA.cm⁻² was obtained in the sample with 1.00 wt.% co-addition level. It was also found that the co-added samples showed higher J_c (≤ 4 T) at 20 K compared to that of the pure one. The roles of Dy₂O₃ and La₂O₃ co-addition for enhancement of flux pinning and J_c in MgB₂ are discussed.

Keywords: MgB₂; Carbon-encapsulated boron; Dy₂O₃; La₂O₃; Critical current density

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Superconductivity in Layered Nb₂PdS₅ system

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Abstract

In 2013, the superconductivity in quasi one dimensional Nb₂PdS₅ sample was found and reported at 6.6 K [1]. The transition temperature is low, but the upper critical field is high in Nb₂PdS₅ superconductor. The theoretical and experimental studies concluded that there are two main parameters (T_c and H_{c2}) which decides the practical applications of any superconductors. For application point of view, the high transition temperature and high upper critical field are highly desirable. In general, high transition temperature suggest low operating cost and high upper critical field claimed the robustness of superconductors against magnetic field. Also, for some applications like high power transmission cable, researchers have challenged to synthesize flexible superconducting materials. Interestingly, the fibers of Nb₂PdS₅ superconductor are flexible in nature that can be reshaped easily. This superconductor is useful for power transmission in electronic devices [2]. Nb₂PdS₅ superconductor is a quasi-one dimensional superconductor which has been synthesized using standard solid state reaction route. Nb₂PdS₅ crystallizes in centrosymmetric monoclinic structure within space group C2/m and scanning electron microscopy displayed its slabs like laminar growth. From electrical resistivity and dc magnetization studies, the synthesized compound shows superconductivity below 6 K. This compound is quite robust against magnetic field with dH_c/dT of ~ 42 kOe/K. The estimated upper critical field [$H_{c2}(0)$] is 190 kOe, clearly surpassing the Pauli-paramagnetic limit of $1.84T_c$. The specific heat under different magnetic fields for this superconductor is reported. Low-temperature heat capacity in superconducting state of Nb₂PdS₅ under different magnetic fields showed s-wave superconductivity with two different gaps. Two quasilinear slopes in Sommerfeld coefficient (γ) as a function of applied magnetic field and two-band behavior of the electronic heat capacity demonstrate that Nb₂PdS₅ is a multiband superconductor in a weak coupling limit with $\Delta C/\gamma T_c = 0.9$. The lower critical field (H_{c1}) is extracted from DC magnetization measurements at various temperature below T_c . It is found that $H_{c1}(T)$ of Nb₂PdS₅ material seemingly follows the multiband nature of superconductivity.

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Refinement of Commercial Boron using High Energy Ultrasonication

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Abstract

Background/ Objectives and Goals

Increasing grain boundary area can enhance superconducting critical current density, J_c , in MgB_2 superconductor and this can be done via refining initial boron precursor particles. However, refining boron using conventional ball-milling results in formation of B_2O_3 which is responsible for increase in MgO non-superconducting impurity in bulk MgB_2 system. In this work, we reduce the size of commercial boron precursor powder by employing high energy ultra-sonication in ethanol media, in order increase the J_c without resulting in high content of MgO in the final product.

Methods

For this ultra-sonication experiment, we had utilized commercial boron (Furu-uchi chemicals, 300 mesh, 99% purity) and an ultrasonicator (Mitsui ultrasonic Homogenizer). The working principle comprises generation of ultrasonic waves via a vibrating metal probe in the beaker containing boron powder dispersed in ethanol. To investigate the possible best scenarios, we had systematically varied ultra-sonication time such as 30, 60, 90 and 120 minutes, maintaining constant power and frequency of 150 W and 20 kHz respectively. Alternating power mode was employed, that is, the power is switched between ON and OFF modes alternately for every 30 seconds. This ensures that the metal tip generating pulses gets enough time to cool off the heat produced from bombardment of dispersed particles. The effective ultrasonication duration can be assumed as 15, 30, 45, and 60 minutes. Subsequently, the powder was heated at 100 °C for one hour in a muffle furnace to ensure ethanol removal. Later, the powders were characterized by X-ray Diffraction (XRD), Scanning electron microscope (SEM) to confirm the size reduction.

Expected Results/ Conclusion/ Contribution

Ball-milling is a conventional technique used to refine particle size. However, in the case of boron powder, this technique is not commercially viable because of oxide impurities (mainly B_2O_3) formation. XRD analysis revealed that the amount of B_2O_3 increase with an increase in milling time, which results in poor T_c in final bulk MgB_2 . However, ultra-sonication process doesn't show such issues, making it very attractive for safe particle refinement. XRD results depict absence of B_2O_3 diffraction peak even after 1 hour of ultrasonication (100% intensity peak- usually at approx. $2\theta = 27.8^\circ$). This feature is of high importance due to the presence of oxides in precursor promote formation of MgO , which is detrimental to the superconducting properties. To examine the particles size reduction, we had performed microstructural studies using SEM micrographs of pure and ultrasonicated boron. The particles sizes were significantly reduced as it can be observed.

Keywords: Ultrasonication; Refinement; Commercial Boron; B_2O_3

Biography

Mr. Sai Srikanth Arvapalli received his Bachelor's and Master's degree on 2017 from the Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras (IITM), Chennai, Tamil Nadu, India. He is now pursuing his Doctoral studies (3rd year) in Superconducting materials at Shibaura Institute of Technology, Tokyo, Japan. He is specially working on improvement of superconducting properties of bulk MgB_2 . His research interests are Magnetic materials, Superconducting materials.

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Investigating Field Dependence of Critical Current Densities in High T_c Superconductors

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Abstract

Background/ Objectives and Goals

In the upcoming generation, high T_c superconductivity plays a crucial and promising role in numerous industrial applications ranging from MagLev trains to magnetic resonance imaging (MRI). Especially, the bulk high- T_c superconductors (HTS) as permanent magnets are suitable due to their ability to trap magnetic fields being several orders of magnitude higher than those of the best hard ferromagnets. The high T_c material could obtain very powerful compact superconducting supermagnets which can be operated by cheaper liquid nitrogen temperature or below. As a result, new advanced technology can be utilized in a more attractive manner for variety of industrial applications. An understanding of the magnetic field dependence of critical current density is important to develop better adapted materials. To achieve this goal, a variety of $j_c(H)$ behaviors of bulk MgB_2 , $YBa_2Cu_3O_y$, $GdBa_2Cu_3O_y$ and thick film $ErBa_2Cu_3O_y$ samples were modeled regarding thermally activated flux motion. In essence, bulk MgB_2 follows a certain criterion where an exponential decaying model is applied. On the other hand, RE-123 and Er-123 require unique model where one is increasing and other is decreasing in a circumstance. The modeling of various superconducting materials could be comprehended in terms of the pinning mechanisms. Finally, I will introduce flux pinning and superconducting properties as a result of synthetic oil immersion of bulk MgB_2 .

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Optimization of Infiltration Grown Ternary Mixed Rare-Earth Bulk (Gd,Y,Er)Ba₂Cu₃O_y Superconductor

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Abstract

Background/ Objectives and Goals

High temperature bulk superconductors are attractive for numerous engineering applications that comprises of magnetic shielding in electric machines and high-field devices, high-field magnet systems for medical devices with drug delivery, and flux trapped field magnets for replacing conventional permanent magnets. The REBa₂Cu₃O_y (RE123) (where RE is rare earth element such as Y, Nd, Eu, Gd, Er, Yb, etc.) is one such system that is classified as high temperature superconductors. Now, the most effective way for synthesizing a good performance bulk RE-123 superconductors is via infiltration growth (IG) process with an effective integration of careful control of the secondary phase, RE₂B₃CuO₅ (RE-211) embedded in RE123 matrix. In previous studies, the ternary mixed bulk superconductors such as (Sm,Eu,Gd)Ba₂Cu₃O_y, (Nd,Eu,Gd)Ba₂Cu₃O_y, (Nd,Sm,Gd)Ba₂Cu₃O_y etc. exhibited very high critical current densities (*J_c*) and high trapped field performance (*BT*) than the conventional single rare earth element bulk systems such as YBa₂Cu₃O_y, GdBa₂Cu₃O_y. Hence, in prospects for improving the superconducting performance of bulk superconductors, we had explored a new ternary mixed bulk system comprised of Gd, Y, and Er elements grown by IG process.

Methods

The Gd₂O₃, Y₂O₃, Er₂O₃, BaCO₂ and CuO were mixed to get the nominal composition of Gd₂BaCuO₅ (Gd211), Y₂BaCuO₅ (Y211), Er₂BaCuO₅ (Er211), ErBa₂Cu₃O_y (Er123) and Ba₃Cu₅O₈. After mixing and calcination for 4 times at 820°C, 840°C, 860°C and 880°C for 12 h each, the calcined Gd211, Y211 and Er211 powders were weighted in a nominal molar ratio of Gd211:Y211:Er211 = 1:1-X:1+X where X = 0, 0.05, 0.1, 0.15, 0.02 and then mixed which were later used as secondary phase. Liquid phase (LP) is made up of Er123 and Ba₃Cu₅O₈ were mixed with 1:1 ratio. The secondary phase and LP source mass were pelletized separately under an applied pressure 20 kN with 20 mm diameter. The ratio of secondary phase and LP was 1:1.4. The secondary phase was placed on the LP. After that, Nd123 seed was plate on top and center of the secondary phase. The liquid phase reservoir was supported by Y₂O₃ and MgO single crystal for achieving single grain growth. The samples were placed in a box furnace and heated to 880°C in 8 h and dwelled for 15 min to maintain temperature, then ramped to 1050°C in 50 min and dwelled 1 h for infiltration of LP into secondary phase. The sample was slowly cooled through peritectic temperature at rate 0.3°C/h. X-ray Diffraction was used to test the quality and crystalline nature of produced bulk. For superconducting parameters such as the trapped field properties: Superconducting transition temperature (*T_c*) and critical current density (*J_c*) were measured. To support the mechanisms behind the presented results, microstructural analysis was studied using field-emission scanning electron microscope (FESEM).

Expected Results/ Conclusion/ Contribution

The bulk (Gd_{0.33}Y_{0.33}-xEr_{0.33}+x)Ba₂Cu₃O_y superconducting materials were synthesized using optimal temperature and time via IG process. All samples exhibit nature of single grain growth in *ab*-axis and *c*-axis, which are expected to show high *J_c* and *BT* values. Trapped field of (Gd_{0.33}Y_{0.28}Er_{0.43})Ba₂Cu₃O_y bulk superconductor (under an applied field 0.5 T at 77 K) was around 0.36 T. In an applied field 1 T, one can expect trapped field value of more than 1.5 to 2 times that of what we observed when 0.5 T was applied. Later, we have to cut small samples for measured *T_c* and *J_c* using SQUID magnetometer (model MPMS5). Microstructural results will also be discussed in this section.

Keywords: (Gd, Y, Er)123, Infiltration Growth; Critical current density; SEM

Biography

Sunsanee Pinmangkorn is currently a doctoral student in the Graduate School of Science and Engineering, Regional Environment System at Shibaura Institute of Technology. I'm working on the melt processed bulk (RE)BCO superconductors. My main research focuses on the development of bulk RE-123 material for superconducting super-magnet applications.

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Special variation of IG processed bulk $\text{YBa}_2\text{Cu}_3\text{O}_{7.6}$ produced utilizing the mixture of $\text{YbBa}_2\text{Cu}_3\text{O}_{7.6}$ and $\text{Ba}_3\text{Cu}_5\text{O}_8$ (1:1.3) as a liquid phase

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Abstract

Background/ Objectives and Goals

High- T_c superconducting bulk magnets with *superior performance* are extremely attractive for a variety of industrial applications including medical, transport, space and research applications. One of the key issues for large-scale applications of these materials comes with high critical current density (J_c) combined with uniform performance. This can be filed by recently developed high performance top-seeded infiltration growth (IG) process bulk $\text{YBa}_2\text{Cu}_3\text{O}_{7.6}$ (Y-123) produced by optimized new class of liquid phases i.e. is the mixture of $\text{YbBa}_2\text{Cu}_3\text{O}_{7.6}$ (Yb-123) and $\text{Ba}_3\text{Cu}_5\text{O}_8$. Up to date, such a new class of liquid phase utilized single grain IG processed bulk Y-123 superconductors have not studied the uniformity of superconducting performance. In this presentation, we had prepared bulk $\text{YBa}_2\text{Cu}_3\text{O}_x$ samples via Yb-123+liquid (1:1.3) as a liquid source and had characterized uniformity by utilizing superconducting transition temperature (T_c), critical current density (J_c), scanning electron microscopy (SEM), and flux pinning analysis at 77K.

Methods

In order to produce single grain bulk Y-123 by IG process in this experiment, the liquid phase (LP) sources i.e. Yb-123+liquid (1:1.3) as a liquid source was selected. The Y211 pre-form was then placed on top of liquid phase preform. After this, a Nd-123 melt-textured seed was placed at center of top surface of Y-211 pre-form to grow bulk Y-123. This technique is a combination of cold top-seeded method and the infiltration growth (IG). For IG process, the sample was heated to 880 °C at the rate of 200 °C/h and held there for 10 min and further heated for 50 min to temperature of 1060 °C and held for 50 min. Then, the temperature was lowered in 50 min to 1005 °C, and slowly cooled to 980 °C at a cooling rate of 0.25 °C/h. The melt-textured samples were annealed at 450 °C for 150 h in flowing pure O_2 gas. To check its uniform performance of bulk Y-123, we had selected several specimens in top, middle and bottom of the bulk sample and characterized T_c , J_c and microscope by SEM.

Expected Results/ Conclusion/ Contribution

Here, we provide temperature dependence of magnetization measurements that indicated a sharp superconducting transition with T_c (onset) that varies around 89 to 91K for six specimens selected in top, middle and bottom of bulk Y-123 material. In addition, the critical current density was calculated on the basis of Bean's model and resulted as around 38,000 A/cm² to 41,000 A/cm² at 77 K (self-field), H//c-axis. The variation of critical current density in varying positions will be explained on the basis of microstructural variation observed by SEM. In essence, the variation of T_c and J_c values are quite negligible as compared to bulk Y-123 produced by top seeded melt processing technique. The present results clarified that new class of liquid phase utilization for the production of IG process Y-123 has a big potential for several industrial applications for the utilization of superconducting super-magnets.

Keywords: Y-123; IG process; Special variation; Critical current density; Micro-structure

Biography

M. Sushma is a young, internationally recognized researcher who is fascinated to enhance the disciplinary intersection of science and technology that is further supported by Sustainable Development Goals (SDGs) recognized by UNESCO. Interested in engineering and potential applications within the fields of robotics, AI, medicine, and superconducting super-magnets. Furthermore, my past activities reflect that I am a strong advocate of gender equality with a distinguished goal of promoting women empowerment in STEM at underprivileged communities. My work regarding growth of IG processed bulk superconductors had been accepted in several highly prestigious international conferences, including PASREG 2017, ISS 2017, GIS 2018, ISS 2018, ASC 2018 as oral and invited presentations.

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Enhanced in-vitro Biocompatibility of Boron Incorporated Hydroxyapatite via Defect Chemistry Induced by a Modified Co-Precipitation Method

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Abstract

Background/ Objectives and Goals

Apatites with various ionic incorporations have been widely investigated. However, there is limited study on the effect of boron incorporation in hydroxyapatite (HA) structure. Although boron incorporated HA has been discussed in limited literature, there has been no report evaluating the in-vitro biocompatibility of the boron incorporated HA with different defect chemistry.

Methods

Boron incorporated HA (B-HA) was synthesized via modified co-precipitation method using HA stoichiometric value of 1.67 for the (Ca+B/P) and Ca/(P+B) ratio for the precursor solutions. Thus, a boron-precursor was used as a replacement for the 0.25%, 1%, and 3% of either the Ca deficient precursor (B→Ca) or P deficient precursor (B→P) to synthesize Ag-HA particles. The synthesized B-HA nanoparticles were cold pressed and sintered in air at 700°C to 1300°C to further activate the B-incorporation.

Phase analysis was confirmed by X-Ray diffraction (XRD) and change in lattice parameter was calculated from XRD results. Densification of B-HA was calculated and investigated by scanning electron microscopy (SEM). The chemical composition of B-HA was measured by energy-dispersive X-ray spectroscopy (EDS). Fourier transform infrared (FTIR) spectroscopy was used to identify the functional groups and the presence of bonds formed in the B-HA.

The viability of osteoblast cells (ATCC, CRL-11372, 3500 cells/cm²) on the B-HAs in Dulbecco's modified Eagle's medium (supplemented with 10% FBS and 1% P/S from HyClone) were conducted for 4 h to evaluate the in-vitro biocompatibility of B-HAs.

Expected Results/ Conclusion/ Contribution

It was found that relatively more boron can be incorporated into the HA structure when synthesized from P deficient precursor solutions (B→P HAs). On the other hand, a single HA phase with B→P HA was stable at sintering temperatures up to 1100°C without any secondary phase formation, whereas B→Ca HAs exhibited thermal decomposition of HA to β-TCP. B-incorporation delayed the β to α-TCP transformation, similar to Ca-site incorporation. The change in lattice parameters expressed the results of defect chemistry with non-uniform changes depending on precursor replacement and incorporated boron content. FTIR analyses revealed that B-HAs showed responsible bonds of B-incorporation described as structural incorporation and B-O attached to HA surface. The density of B-HAs improved with increase in sintering temperature and the grain size and densification was correlated with SEM images of B-HAs.

In vitro biocompatibility of the B-HAs demonstrated enhanced osteoblast adhesion with the increase in boron content for B→P HAs. The boron is reported to improve osteoblast activity. Therefore, it is expected to observe the enhanced biocompatibility with the increase in boron content. However, the B→P HAs exhibited superior biocompatibility compared to B→Ca HAs, which suggested being because of the defect chemistry of HA via P-precursor replacement enhanced the bioresorbability of HA, as a result increase boron release to in-vitro environment. It has been reported that boron improved antibacterial properties of biomedical materials. Thus, B-HA with defect chemistry can be a candidate with its enhanced biocompatibility and antibacterial property.

The present findings suggest the possibility to tailor the properties of HAs in order to optimize both osteoblast adhesion and bactericidal ratios to develop an effective bioactive and antibacterial orthopedic/dental material that deserves further attention.

Keywords: Hydroxyapatite; Boron; Incorporation; Defect chemistry; Cytotoxicity

Biography

Ozkan Gokcekaya has completed his PhD at the age of 29 years at Tohoku University.

He is biomaterial scientist and 3D printing specialist, assistant professor focusing on 3D printing of metals and ceramic materials with improved material properties at Osaka University. He has published papers on ionic-incorporation to calcium phosphates in reputed journals and serving as an editorial board member of *International Journal of Nanomaterials, Nanotechnology and Nanomedicine*.

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Open Problems in Modeling of Mechanical Properties of CNT-based Nanocomposites

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Abstract

The particular scientific attention is directed to utilization of carbon nanotubes (CNTs). Due to unique properties, it is believed that few weight percentages of CNTs can significantly improve the mechanical properties of nanocomposites. CNTs are widely used as a reinforcing phase in polymeric, ceramic and metallic matrix composites. However, most of them are the polymeric based composites. Recently, researchers have extensively focused on CNT/epoxy nanocomposites because of their broad applications in the electronics, aeronautics, and automotive industries. The incorporation and uniform dispersion of CNTs in epoxy thermosets could enable engineers to create new materials that potentially imitate the most advanced materials in nature. However, the increase of high-performance materials by the integration of CNTs into polymeric matrices is challenging because thermodynamic and kinetic barriers make difficult the effective dispersion of nanotubes. Typically the volume fraction of CNTs in nanocomposites is low. At higher CNT fractions the mechanical properties of the nanocomposite were observed to deteriorate due to the formation of CNT agglomerates, which act as stress concentrators. The improvement of mechanical properties as expected from the rule of mixture (ROM) is not achieved, mostly due to the occurrence of nanotubes aggregation. Thus, theoretical models describing effective mechanical properties of CNT based nanocomposites are still a current issue. The distribution of reinforcement in composite materials is of high attention and has a significant influence on their mechanical behavior [1-4]. In real fibrous composite materials, the fiber distribution is mostly random and usually unknown. Therefore, some idealizations of fiber distribution in the polymeric matrix are assumed in the analysis of composite materials. The properties of CNT-based nanocomposites are elaborated based on experimental tests and theoretical descriptions. Today, to accurately characterize advanced composites, the numerical calculations are indisputable necessary since the experiments at nano-level produce high costs. Also, experimental investigations may be impossible to conduct and analytical computations are challenging to formulate or excessively complex to solve. The advantage of numerical simulations of nanocomposites combines the easy realization and cost-efficiency.

Here, the attention is focused on the characterization of elastic properties of epoxy nanocomposites with small amount of carbon nanotubes involving FE modeling contrasted with classical micromechanical approaches. The present paper considers the FE modeling of nanocomposites and the comparison with analytical modeling, atomistic-continuum models and molecular dynamics simulations. Since the global mechanical response of the CNT/nanocomposite is expected the continuum mechanics approach is adequate. The carried out studies based on the numerical homogenization procedure employ a spatial periodically arranged various representative volume elements and the finite element method. The conducted analyses consider the influence of reinforcement distributions in the RVE on the effective properties. The transversely isotropic material with aligned and uniformly distributed carbon nanotubes is considered. For the transversely isotropic material, five elastic material constants are needed to define the elastic behavior. The analytical micromechanical models are consistent with numerical results only for the axial Young's modulus and Poisson's ratio whereas remaining elastic constants are lower than the numerical predictions. The comparison with available data revealed that present numerical values are placed between the values predicted by the atomistic-continuum models and by the molecular dynamics simulations. However, contrasting of current results and values from other theoretical models with the experimental ones revealed that CNT-based nanocomposites tested experimentally are poor in the enhancement of mechanical properties of polymeric matrix what do not fulfill the theoretical predictions.

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Keywords: Nanocomposites; Carbon nanotubes; Homogenization; Mechanical properties; FEA

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Carbon Nanotubes Continuously Filled with micrometre-long Ferromagnetic Fe₃C Nanocrystals

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Abstract

Carbon nanotubes filled with ferromagnetic metal or alloy nanocrystals have recently attracted significant attention thanks to their tunable coercivities and saturation magnetizations. Continuous filling of the nanotube's central capillary remains an important step towards application of this category of nanomaterials in quantum disk data-recording systems. Extensive filling has been achieved using a growth method that exploits self-organisational processes in the viscous boundary layer between flowing thermally decomposed metallocene vapour and a textured substrate in a conventional CVD reactor [1]. K-type substrate roughness produces flower-like morphologies continuously filled with Fe-based nanowires of length many micrometres [2]. Despite the significant progress, the dependence of morphology on metallocene evaporation temperature and post-synthesis thermal profile have not been investigated. Here, we report flower-like structures continuously filled with micrometre-length nanocrystals of Fe₃C produced in a locally perturbed vapour. The morphology, cross-sectional and structural characteristics of the material are probed by electron microscopy and X-ray diffraction techniques. By tuning the evaporation temperature of the ferrocene precursor from 140 °C to 500 °C, a transition from an open- to a closed-flower morphology was observed. Through Rietveld refinement of X-ray diffractograms, the volume fraction of Fe₃C was found to be 98% when the post-synthesis thermal profile comprised slow-cooling from 990 °C to 800 °C followed by a quench from 800 °C to room temperature.

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Keywords: Carbon nanotubes; Fe₃C; Boundary layer; Continuous filling

Biography

Filippo S. Boi obtained his PhD in Queen Mary University of London, School of Physics and Astronomy, in the area of nanofabrication of iron filled carbon nanotubes in 2013. Filippo joined Sichuan University as Associate Professor in 2014. His research has focused on the magnetic-properties of carbon materials, particularly on carbon nanotubes, onions and graphite-superlattices. Filippo was promoted to Professor in 2019. His research work has resulted in 69 publications, of which many in significant SCI-journals. In 2014, 2017, 2018 and 2019 Filippo was awarded with the NSFC grant for young-researchers, the NSFC grants for international-scientist and the Sichuan-Research-Technology grant.

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Nano-structured SiAlOC glasses-based coatings for SOFC's interconnects

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Abstract

Background/ Objectives and Goals

Nowadays, a considerable effort is still put into a finding the solution for the problem of the high-temperature corrosion of Solid Oxide Fuel Cells' (SOFCs) interconnects. In this work, protective coatings based on Polymer Derived Ceramics (PDCs) from SiAlOC system were applied in order to enhance the corrosion resistance of metallic interconnects. Comparing to commonly investigated spinel or perovskite-based coating materials, PDCs provide with the completely different approach based on the flexibility of their structure including two forms of carbon – carbidic in Si-C bonds yielding a superior thermomechanical stability and so called “free carbon phase” responsible for material's electrical conductivity.

Methods

The coating material was formed by means of the sol-gel method using alkyl-modified alkoxy silanes as the starting precursors. The sol hydrolyzed in the acidic atmosphere was used in order to deposit thin layers on the grinded substrate (ferritic Crofer 22APU steel) during the application of the dip-coating technique. Subsequently, samples were thermally treated (drying for one week at 70°C in the air/pyrolysis for 30 minutes at 800°C in argon), yielding in the formation of SiAlOC glasses' coatings. For the assessment of the corrosion resistance, both coated and bare samples were used during isothermal thermogravimetric analyses (TGA) and cyclic oxidation tests at 800°C in the air atmosphere for 500h and 500 1h-cycles, respectively. Apart from the mass changes, the full evaluation of structure (GIXRD; FTIR, Raman) and microstructure (SEM+EDS, Confocal Microscopy) of surface and cross sections of samples before and after oxidation, was performed.

Expected Results/ Conclusion/ Contribution

The results of the following work proved the significant improvement in the corrosion resistance of the Crofer 22APU steel during isothermal exposure due to considerably lower mass gain (over five times) and nearly 1.5 orders of magnitude lower value of the parabolic rate constant k_p in comparison to the uncoated sample. It is highly probable that the formation of the multilayered protection (SiAlOC glass/MnCr₂O₄+Cr₂O₃/Crofer 22APU) already after the pyrolysis, confirmed via structural analysis - GIXRD and Raman profile depth, led to such promising results. The microstructural studies (SEM+EDS) revealed the nucleation of the noticeably thinner scale (max. 0.7 μm for coated vs. max. 3.5 μm for uncoated specimen), which is in a good agreement with mass changes. In case of thermal shocks conditions, the application of SiAlOC glasses also enhanced the oxidation resistance – mass gain was lowered for around five times (similarly to isothermal conditions) and formed scale exhibited good adhesion to the substrate. However, in order to confirm the first outstanding findings and fully elucidate the potential of PDCs as protective-conducting coatings, electrical conductivity has to be determined. Thus, Area Specific Resistance measurements in the function of temperature (up to 800 °C) and time (within 500 h) are planned to be executed.

Keywords: Polymer Derived Ceramics; SiAlOC glasses; Protective coatings; SOFC; interconnects

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Film Formation on Mg Alloy Surface by Multifunction Cavitation using Phosphoric acid

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Abstract

Background/ Objectives and Goals

Recently, mechanochemical multifunction cavitation (MC-MFC) was developed to improve the corrosion resistance of the magnesium surface. MFC is a technology that combines water jet peening and ultrasound cavitation. MC-MFC is a technology that adds phosphoric acid to water. It can improve the corrosion resistance by forming a phosphate film on the Mg surface. Conventional anodic oxidation, plating, and chemical vapor deposition can improve corrosion resistance by forming a film on the Mg surface, but it is difficult to improve characteristics such as compressive residual stress on the surface. MFC-treated surfaces have previously imparted various properties such as imparting compressive residual stress necessary to improve the fatigue strength to Al alloys and Cr-Mo steels. In this study, the effect of film formed on MC-MFC processed surface on compressive residual stress was investigated. In addition, we compare the characteristics of surfaces processed using conventional anodic oxidation (AO) treatment, mechanochemical water jet peening (MC-WJP), and MC-MFC.

Methods

An Mg alloy (AZ31) was used as the test material. Fig. 1 shows a schematic diagram of MC-MFC processing. In WJP processing, water is stored in a tank. A water jet nozzle is fixed in the water. Room-temperature, high-pressure water is directed toward the specimen surface to generate cavitation bubbles to process the specimen surface. When the cavitation bubbles collide with the specimen surface, the local region plastically deforms. When the bubbles collapse, compressive residual stress is applied to the plastically deformed region due to elastic restraint from the surrounding material. In MFC processing, an ultrasonic wave transmitter is used to propagate waves in a direction perpendicular to the orientation of the water jet nozzle. Ultrasonic waves are applied to the high-pressure water jet used to process the specimen surface. This technology is very similar to WJP. It is possible to expand the specimen surface through repeated isothermal expansion and adiabatic compression to form large bubbles at temperatures of several thousand degrees Celsius and pressures of several billion pascals when the cavitation bubbles are irradiated by ultrasonic waves. Therefore, the growth process of cavitation bubbles is different from that in WJP. In addition to these techniques, processing was carried out while introducing a liquid comprising a 10:1 mixture of water and phosphoric acid into the conduit of the water jet nozzle, as shown in Fig. 1. Here, WJP and MFC processing with the addition of dilute phosphoric acid are denoted MC-WJP and MC-MFC, respectively. The discharge pressure of the pump was approximately 35 MPa and the nozzle diameter was 0.8 mm. The processed specimens were analyzed by SEM-EDS, X-ray stress analyzer and micro Vickers hardness test.

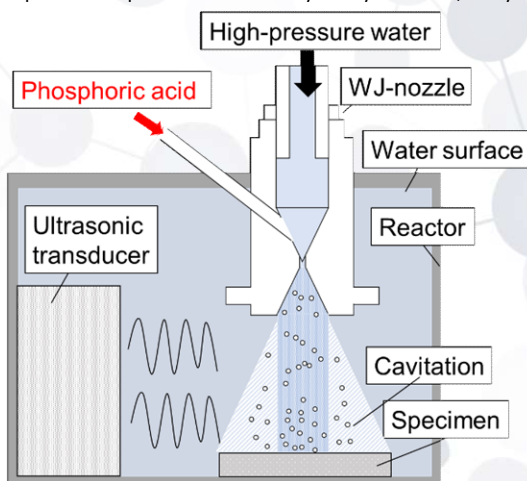


Figure 1. Equipment for surface processing with MC-MFC.

Expected Results/ Conclusion/ Contribution

SEM-EDS analysis confirmed the existence of P and O in the film on each treated surface; parts of the AO-treated surface did not have a film.

- The film was thickest on the surface treated with MC-MFC.
- The surfaces treated with MC-MFC and MC-WJP had increased hardness and compressive residual stress. Although the hardness of the surface treated with AO increased, the compressive residual stress did not.

Keywords: Multifunction cavitation; Water jet peening; Mg alloy; Corrosion resistance; Phosphate film; Compressive residual stress

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Sensitized Organic Emitters for Efficient Electroluminescence

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Abstract

To meet the requirements of low-cost, high efficiency, and mass-production, we developed a series of organic emitters, including thermally activated delayed fluorescence (TADF) polymers with small singlet-triplet gaps and conventional emitters with large singlet-triplet gaps, which are easily solution-processable for organic light-emitting devices (OLEDs).

The side-chain engineered sky-blue TADF inherited almost the identical features of the TADF small molecule used as the side-chain component. To further enhance singlet harvesting, a TADF small molecule as the sensitizer was blended into the traditional host-guest system. Eventually, we improved the PLQY of the polymer-based film from 74% to 95% and thus a maximum external quantum efficiency (EQE) over 16.

A purely organic fluorophore with the intensive near-infrared emission peaking close to 800 nm in solid state and novel aggregation-induced emission features was designed and synthesized. To improve the electroluminescence efficiencies of the solution-processed device with this unique near-infrared emitter, a commonly used host material and a phosphorescent iridium complex as a sensitizer were co-doped with the near-infrared emitter. In this optimized device architecture, the cascade energy transfer was guaranteed by Förster mechanism. This unique scheme achieved not only resonant and unexpected triplet-singlet energy transfer but also dramatically enhanced exciton utilization efficiency. Finally, the near-infrared electroluminescent devices realized a factor of 2.7 enhancement of the external quantum efficiency, compared with the one possessing no sensitizer. The sensitized fluorescence approach provides us a very unique platform to manipulate the exciton dynamics, which is beneficial for highly efficient electroluminescence with reduced exciton lossy channels. It is essential to find the suitable combination of the emitter with fast radiative decay and the sensitizer which could be either TADF or phosphorescent compound with high photoluminescence quantum yields.

Keywords: Organic light-emitting devices; Sensitization; Energy transfer; Exciton utilization

Biography

Dr. Guohua Xie obtained his Ph.D. degree from Jilin University (China) in 2011. From August 2011, Dr. Xie carried out his postdoctoral research at TU Dresden (Germany), sponsored by Alexander von Humboldt Foundation. From January 2013 to January 2015, Dr. Xie worked for the University of St Andrews. Since January 2015, he is an associate professor at the College of Chemistry and Molecular Sciences of Wuhan University (China). Dr. Xie gained extensive experience in the interdisciplinary research of materials and physics of organic optoelectronics. He has coauthored more than 140 peer-reviewed publications (h-index of 32.)

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Waste to wealth : Development of value additive products from lignocellulosic biomass with the application of carbon materials applied sciences

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Abstract

Bioscience and Biotechnology with the conception of converting Lignocellulosic to value additive products to improve the Bioeconomy with the target of multi Bn USD wealth generation is the new Power to the economic transformation. Lignocellulosic biomass like rice straw, wheat straw, corn cobs etc., are major feedstock biomass for the generation of value added biomaterial and of course the source of energy. Biomass is a primary source of food, fodder and fibre and as a bioenergy source provides about 10.2% (50.3 EJ/yr) of the annual global total primary energy supply (TPES) from a wide variety of biomass sources [1].

The large amount of waste of the fruit and vegetable industry is economically viable and reasonable to valorize for the preparation of fruit-based polysaccharides nanocomposite, microfibrillated cellulose, nanofibrillated cellulose and cellulose nanocrystals. Cellulose nanostructures effectively recognized as a possible bio-based additive, biopolymer due to their mechanical properties, better stiffness, thermal and water barrier properties the fundamental criteria for the food packaging film. Cellulose-based materials are highly in demand because of their biocompatibility, edibility, non-toxicity, the most abundant among the lignocellulosic biomass in nature, sustainable and available with relatively low cost. The major emphasis of this project is to convert the available cellulose of fruit and vegetable pomace (35%-45%) to nanocellulose with higher degree of crystallinity and low lignin content. The cellulose from the biomass source of fruit pomaces are with thinner microfibrils, with better filler properties.

Nanocellulose was successfully extracted from the lignocellulosic biomass sources viz. rice apple pomace and fruit industry waste using a combination of chemical treatments such as alkaline treatment, bleaching and acid hydrolysis. The shape, size and surface properties of the nanocellulose generally depend on the source and hydrolysis conditions. Hence the reaction conditions were further optimized through response surface methodology. A comparative study of the fundamental properties of raw material, bleached and nanocellulose was carried out by means of compositional analysis, Fourier transform infrared spectroscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction, and thermo gravimetric analysis. Through the characterization of the nanocellulose obtained from different sources, the isolated nanocellulose showed an average diameter in the range of 10–25 nm, high crystallinity, high thermal stability and a great potential to be used with other biopolymers for development of nano-biocomposites for several industrial applications. This work report provides an insight into the effective utilization of a variety of plant biomass as a potential source for nanocellulose extraction.

The different sources of biomass viz. rice straw, broom grass, wheat straw and apple pomace were used to produce CNC and CNF as a source of cellulose. Chemical therapy, i.e. pre-treatment, delignification and acid-hydrolysis, were used to prepare CNC and CNF. Methodology of the response surface, the central composite design is discovered to be helpful in defining the key variables. SEM, HR-TEM, described the morphology and topography of nanocrystals. SEM studies demonstrate supporting proof for Nano-scale CNCs with HR-TEM assessment. The average diameter of the CNCs was found in the range of 5–20 nm. FTIR-ATR has evaluated the structural modifications and XRD, and thermal analysis was measured by Thermal gravimetric analysis (TGA). Hence, this studied revealed that preparation of CNCs and CNF from different source of biomass by chemical method and mechanical method may be very effective process to be carried out at large scale.

Cellulose nanocrystal type	Diameter (nm)	Crystallinity index (%)
Rice straw CNC	5-15 nm	76%
Broom grass CNC	5-11 nm	89.2%
Apple pomace CNC	10-50 nm	82.6%

Table 1. Diameter (nm) and crystallinity index (%) of different type of cellulose nanocrystals.

Keywords: Lignocellulosic Biomass; Cellulose; Nanocellulose; TEM; TGA

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Biography

Dr. Saswata goswami has completed his PhD from National Institute of TechnologyDurgapur (West Bengal). He is also FIE (Fellow of the Institute of Engineers, India); Chartered Engineer (Institution of Engineers (India), 2019). He is serving as Associate Plant Manager (Research and Innovations) in Center of Innovative and Applied Bioprocessing, Mohali, Punjab, Govt. of India from past 5 years. He has published more than 15 papers in reputed journals, filed 3 patents and presently serving as an Adjunct Associate Professor of RCB (Regional Centre for Biotechnology). He has also developed In-house Technology, and Up Scale and Commercialize in several Indian Industries. Presently he is adviser various industries like Quad life sciences Punjab, Sri Krishna Pharmaceutical Ltd., Hyderabad, Reliance Industries Ltd. Mumbai and so on. Besides, he has been appointed as the Member of the Board of Studies in Chandigarh University, India. He has more than 20 years of industrial experience and also taught for 5 years in Birla Institute of Technology, Mesra, India, before joining CIAB, India.

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Online Summit on Carbon Materials and Nanotechnology

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Behaviour of Geopolymer Concrete with Nano Material Addition

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Abstract

The rapid use of concrete as a construction material is enhancing the demand for Ordinary Portland cement (OPC) production day by day. Towards this, the production of cement industry is contributing in a greater extent in carbon dioxide (CO₂) emissions. It has been observed that the production of one ton of Portland cement emits approximately one ton of CO₂ into the atmosphere. On the other hand, the change in climatic condition due to global warming caused by the emission of greenhouse gases has become a major concern in the present day context. To control this situation several products such as ground granulated blast-furnace slag, rice husk ash, fly ash etc. are used as the alternative components in cement industry. In this situation, environmental friendly low calcium fly ash based geopolymer concrete can be a better option to reduce the environmental pollution issues where full replacement of cement is possible. The term 'Geopolymer' results a chemical reaction in terms of polymerization process where it can be used as an alkaline liquid to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders. In general, geopolymer possess many excellent mechanical properties such as high early strength gains, low creep and shrinkage, and good resistance in acid and sulphate attacks. So, the addition of nano material may also modify the behaviour of geopolymer sample.

In this paper, a detailed experimental investigation on mechanical and durability aspect has been presented for the behaviour of geopolymer concrete with different nano material addition in different percentage. Among different nano materials nano silica (NS), carbon nano tube (CNT) and titanium di-oxide (TO) be considered for the present study. The compressive strength of nano materials mixed (0.75% NS, 3% NS, 0.02% CNT, 1% TO) into geopolymer concrete samples have been compared with its reference counterpart for 7 days and 28 days. Some non-destructive tests such as rebound hammer, ultra-sonic pulse velocity and electrical resistivity test are also done. Rapid chloride penetration test (RCPT) for 28 days and 56 days has been performed for the durability purposes on geopolymer samples as well as samples made with OPC for the inclusion of nano material. Interestingly it has been observed that chemical solutions prescribed for standard RCPT (based on ASTM C 1202) may not be suitable in geopolymer samples due to huge amount of heat generated resulting the leakage of chemical solutions from the cells. Alternate combinations of chemical solutions have been attempted in the present study to overcome this problem.

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Posters

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Role of Dopants in Improving the Critical Current Density in Sintered Bulk MgB_2

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Abstract

Background/ Objectives and Goals

Superconducting properties in bulk MgB_2 superconductors, especially critical current density (J_c) can be controlled by manipulating microstructure. In order to do so, minute addition of secondary phases in MgB_2 for improving J_c has been rigorously studied with various materials ranging from elements to compounds such as Carbon, Oxides, Silver and others etc. These substituents were added to the solid mixture of Mg and B, which are thoroughly mixed before sintering. In this work, we focus on various dopants and their effects on J_c , irreversibility fields (H_{c2}) and T_c of bulk MgB_2 . These results were compared with our current research involving addition of carbon encapsulated boron.

Methods

Bulk MgB_2 was fabricated by an in situ solid state sintering technique. The precursors used were commercial powders (Furu-uchi Chemical Corporation) of amorphous Mg powder (99.9% purity, 200 meshes), 1.5 wt% carbon encapsulated boron (ccb) powder (PAVZYUM). One gram of MgB_2 is synthesized with Mg and ccb components weighing around 0.529g and 0.471g respectively, which is 1: 2 molar ratio as required. These powders were thoroughly mixed and ground in a glove box to avoid oxide formation. This mixture is then pressed into 20mm diameter, 7mm thick pellets using a uniaxial hydraulic press with a force of approximately 20 kN. These pellets were immediately wrapped in Titanium (Ti) foils and heat treated at 775°C for 3 hours in a tube furnace in Ar atmosphere.

Expected Results/ Conclusion/ Contribution

Best performance with a high J_c of 660 kA/cm² at 10 K, self-field. On the other hand, the H_{c2} (calculated by extrapolation) was also improved substantially, almost equivalent to some of the best records reported so far. XRD results explain the maximum carbon substitution in 1.5 wt% ccb based bulk, via (110) peak shift. Similarly, the same bulk exhibited smallest crystallite size which was calculated using Scherrer's equation. M-T loops showed that the reduction in $T_{c, onset}$ was proportional to the carbon substituted into the lattice. In addition, $\Delta T_c < 1$ for all bulks, which proves the high quality. The present results indicate that 1.5 wt% of carbon-coated boron play crucial role in improving the performance of bulk MgB_2 material, which is crucial for several industrial applications that also includes superconducting super-magnets.

Biography

Mr. Sai Srikanth Arvapalli received his Bachelor's and Master's degree on 2017 from the Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras (IITM), Chennai, Tamil Nadu, India. He is now pursuing his Doctoral studies (3rd year) in Superconducting materials at Shibaura Institute of Technology, Tokyo, Japan. He is specially working on improvement of superconducting properties of bulk MgB_2 . His research interests are Magnetic materials, Superconducting materials.

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Recycling Nickel Resource from Electroless Nickel-Plating Waste with Use of Intense Magnetic field Generated by HTS Bulk Magnets

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Abstract

Background/ Objectives and Goals

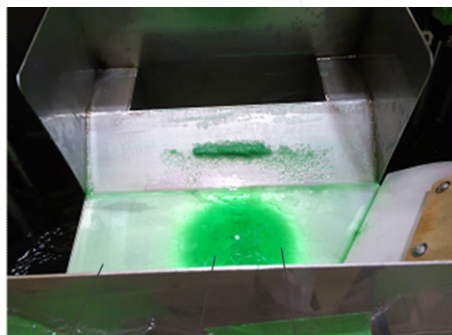
Since nickel (Ni) element is considered as one of the rare earth elements, it is expected to recycle the Ni compounds in the widespread Ni-plating industries. Though the waste liquid drained from electroless Ni-plating process contains Ni ions with high concentration, plating liquid is disposed of after those lives. Therefore, the treatment to derive Ni element is expected if it would be effectively collected.

Methods

In order to derive the nickel compounds from the Ni waste liquid, an actual magnetic separation technique [1] armed with HTS bulk magnet system which generate more than 3 T was developed to collect the Ni-based slurry containing coarse Ni sulfate crystals from, what we call, the regenerated fluid [2]. In the process, the Ni sulfate is collected in the intense magnetic field, and is feasibly recycled back to plating processed as a raw material.

Expected Results/ Conclusion/ Contribution

It was not common thing the crystals of Ni-phosphate slurry can be attracted to magnetic poles, but, intense field over 3T could attract such metallic compound bearing pour ratios of ferromagnetic atoms in its crystal structure. We tried to establish a safe processing with use of a water channel which bears magnetic pole of 3 T under it without any pressurized splash of waste acid. The performance of collection of rate reached more than 8 kg a day [3].



Water Channel Slurry Processed waste liquid

Figure 1. Collection of Ni-sulfate slurry in the liquid channel

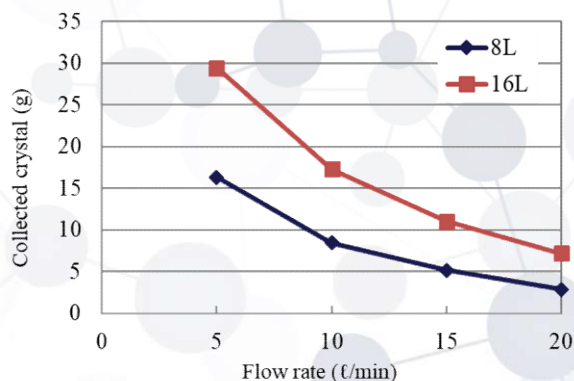


Figure 2. Performance of Ni-sulfate compound against the flow rate

Keywords: Bulk superconductor; Electroless plating; Magnetic separation; Nickel resource; Magnetic field

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Biography

Professor Tetsuo OKA Dr. Eng. graduated from Kyoto University in 1979 in Japan, obtained his Ph. D from Nagoya University in 1992. His majors are metallurgy, magnetism, materials science and their practical applications to superconducting devices. After working for Niigata University, he now belongs to Shibaura Institute of Technology from 2018. A member of IEEE, Cryogenics, Metallurgy, Mechanical Engineering Associations.

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Effects of mixing ratio on capacity and stability of supercapacitor prepared from nano-needlelike nickel/cobalt double hydroxide

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Abstract

Background/ Objectives and Goals

As a crucial integrated part in modern electronic devices, the improvement of energy storage system, such as batteries and supercapacitors, gains increasing interests from researchers and industries. A pseudocapacitor is a kind of supercapacitor which stores the energy by the redox reaction principle. It was reported that nickel hydroxide or cobalt hydroxide can be used as an electrode in pseudocapacitor possessing high theoretical capacitance due to their excellent redox reversibility. The synergistic effect of these two metal hydroxides combination demonstrated the increment in their pseudocapacitor behaviors and cycle performance. Thus, this research studies the effects of mixing ratio between nickel and cobalt in the double hydroxide prepared by the hydrothermal technique on the capacity and stability of supercapacitors resulting from nano-needlelike nickel/cobalt double hydroxide.

Methods

The nano-needlelike nickel cobalt double hydroxide (NCDH) was prepared by the hydrothermal technique. Nickel nitrate hexahydrate and cobalt nitrate hexahydrate were mixed at various ratios, i.e. 100:0, 66.7:33.3, 50:50, 33.3:66.7 and 0:100 respectively. 2 g of the mixture was dissolved in 50 ml DI water. Hexamethylenetetramine (HMTA) and sodium dodecyl sulfate (SDS) were respectively used as reducing agent and surfactant at 30% wt and 12% weight of the mixture. The hydrothermal treatment was proceeded at 140 °C for 14 hours in a Teflon-line autoclave. The obtained product (NCDH) was precipitated and washed with DI water and ethanol several times then dried in an oven at 60 °C for 24 hours. The working electrode was prepared by mixing 80 wt% of NCDH with 10 wt% polytetrafluoroethylene (PTFE) and 10 wt% conductive carbon. The mixing of active materials were coated on 1×1 cm of carbon paper as supercapacitive electrode.

Expected Results/ Conclusion/ Contribution

The cyclic voltammetry (CV) and galvanostatic charge–discharge (GCD) were performed by using three-electrode system in 6 M KOH as an electrolyte. For all samples, the CV results showed the pair board redox peak in the potential window range of -0.3 to 0.45 V at a scan rate of 10 mV·s⁻¹ indicating the characteristic of pseudocapacitive mechanism of nickel/ cobalt hydroxide. CV results revealed the increase of the CV area with the increasing of cobalt content indicating that cobalt has more influence on capacitive performance than that of nickel. At the mixing ratio of 33.3/66.7, NCDH exhibited the largest area, indicating the highest surface electrochemical activity. For GCD, the discharging time was used to calculate the specific capacitance of electrode. The NCDH at the mixing ratio of 33.3/66.7 also showed the highest specific capacitance of 602.1 F·g⁻¹ at a current density of 1 A·g⁻¹. Thus, in term of capacitive performance, the mixing ratio of 33.3/66.7 is the optimum ratio. The x-ray diffraction pattern presents that the crystal structure of NCDH at all mixing ratios corresponding to alpha nickel hydroxide and beta cobalt hydroxide pattern. The shape of beta cobalt hydroxide peak exhibited sharper and more intensity than that obtained from alpha nickel hydroxide signal which is probably the reason why cobalt has more influence on electrochemical properties than that of nickel. In addition, the scanning electron microscope (SEM) exhibited that pure nickel and pure cobalt have coral-like and flakes-like shapes, respectively whereas all NCDH at all ratios have nano needlelike shape growing from edge of plate to the center. This result indicated two stages of NCDH crystallization, sheet-like forming at early stage then needle-like forming while recrystallization causing by hydrothermal treatment. The cyclic stability test was performed by the CV measurement with the symmetric two-electrode system in 6 M KOH at a scan rate of 40 mV·s⁻¹. The results revealed that area of each CV curve was increased as the cycle time increase. The maximum increment of 497.5% was found at the mixing ratio of 33.3/66.7. This is probably due to the fact that the active sites were recovered and regenerated during charge-discharge cycles.

Keywords: Nickel cobalt hydroxide; Symmetric; Hydrothermal; Electrochemical properties

Biography

Mr. Nutthapong Poompiew was born on April 26, 1992 in Nakorn Pathom, Thailand. He received his Bachelor's Degree in Engineering (Petrochemicals and Polymeric Materials) from Silpakorn University in 2014. He then accomplished his Master of Science in Applied Polymer Science and Textile Technology from Chulalongkorn University in 2016. His undergraduate research project and master thesis deal with development of composite materials from bioplastics. He is currently pursuing his doctorate study under the Ph.D. program in Materials Science, Chulalongkorn University. His dissertation deals with the development of electrochemical materials for supercapacitor application.

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High Temperature Behavior of Polymer Derived Ceramics coated novel FeAl Intermetallic Alloy

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Abstract

Background/ Objectives and Goals

Iron aluminides belong to the very interesting group of so-called alumina formers, which are known for an excellent oxidation resistance based on the formation of a thin, protective alumina scale while being exposed to the elevated temperatures. However, the problem of the scale spallation may occur due to the mismatch between alloy and nucleated alumina layer. This work comprises the oxidation behavior of newly developed FeAl based alloy (Fe₄₀Al₅Cr_{0.2}TiB) and the application of Polymer Derived Ceramics (PDCs) in the form of protective layers to suppress the process of the alumina scale spalling off.

Methods

The investigated alloy was produced by means of smelting under vacuum conditions and subsequent homogenization by annealing. In order to enhance its mechanical properties, the alloy was then plastically processed by extrusion. In the first part of the study, alloy was examined with the high temperature XRD analysis performed *in-situ* within 25-1150°C to determine the temperatures of particular Al₂O₃ phase transformations. Additionally, based on the 100% peak shift coming from the alloy, Thermal Expansion Coefficient was evaluated. Samples after the whole experiment were investigated with spectroscopic (Raman) and microscopic (SEM+EDS) studies. In the second part, the material was tested under long thermal shocks conditions within 1000h at 1000°C in the air atmosphere. Furthermore, structure (GIXRD, FTIR and Raman spectroscopy) and microstructure (SEM+EDS) of samples' surface and cross sections were examined. Aforementioned studies were performed for three types of samples: bare alloy both after homogenization and extrusion, and coated one using PDCs from SiOC and SiAlOC system as coating materials.

Expected Results/ Conclusion/ Contribution

The first part of the work revealed the occurrence of specific alumina phase transitions at:

900-950°C ($\gamma \rightarrow \alpha$)

1050-1100°C ($\theta \rightarrow \alpha$)

Moreover, the observed alumina scale was composed of two layers different in morphology and underwent the serious spallation. Despite the presence of peaks assigned only to α -Al₂O₃ phase in the XRD pattern recorded after sample's cooling, Raman spectra revealed the bands attributed to TiO₂ and metastable θ phase. What is more, the determined TEC value was different for two temperature regions ($21.3(9) \cdot 10^{-6}$ [1/K] within 25-500°C and $32.2(2) \cdot 10^{-6}$ [1/K] within 700-1150°C), which was in a good agreement with the DO₃ \rightarrow B2 alloy phase transition determined at around 700°C. The second part of this study, proved the considerable improvement in the oxidation resistance, especially of an alloy after homogenization annealing because of the easily noticeable suppression of alumina scale spallation. What is more, both diffractive and spectroscopic analyses confirmed the formation of mixed θ - and α -Al₂O₃ scale (mostly in case of SiAlOC glasses based coatings), which strongly suggest that applied layers effectively blocked inward oxygen diffusion, which is the main driving force for the complete $\theta \rightarrow \alpha$ alumina phase transition.

Keywords: FeAl intermetallic alloy; *In-situ* XRD; Polymer Derived Ceramics

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Estimation of Residual Stress Generated near Indentation Crack on Single Crystal Silicon Wafer

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Abstract

Background/ Objectives and Goals

This paper provides an estimate of residual stress near indentation crack on the cleavage plane surface of the single crystal silicon through the controlled surface flaw (CSF) method.

Single crystal silicon wafer is expected to be useful for many application by using high precise microstructures since it can be applied to semiconductor process. It is necessary to establish an evaluation method of fracture toughness for microstructures. Fracture toughness is derived from configuration of indentation crack and fracture strength based on linear fracture mechanics. However, the indentation crack generates the residual stresses in evaluation of the fracture toughness for brittle materials such as ceramics and glass. The fracture strength depends on the residual stress distributed on the indentation surface. Therefore, the residual stress should be appropriately removed before the evaluation of the fracture strength.

This study provides the residual stress and a suitable removal amount from the surface based on the experimental results, effects of the removal amount of the surface on the fracture toughness on the of cleavage plane {110} of the single crystal silicon wafer.

Methods

The fracture toughness was evaluated by CSF method. Small specimens of single crystal silicon wafer were used for this evaluation. Each surface was systematically removed by ion shower after an indentation crack was introduced in each specimen's surface. The experiment results were compared with fracture toughness derived by Indentation Fracture method (IF method). Appropriate removal amount from the surface was considered based on the results to provide a guideline on CSF method for single crystal silicon wafer.

Expected Results/ Conclusion/ Contribution

The experiment based on the effects of the removal amount on the fracture toughness values in room temperature conditions was conducted through the CSF method. It confirmed that the estimated residual stress on the indentation surface and an appropriate removal amount from the surface.

Keywords: Residual stress; Fracture toughness value; Brittle material

Biography

Yoshihiro Koga is a student in department of mechanical engineering at Kogakuin University. He especially has an interest in the field of material mechanics. He tries to understand the mechanism of residual stresses on the machining surface and to design micro scale structure with high reliability. He is going to be a graduate student in graduate school of Kogakuin University in April 2020.

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A rectangular area with a grayscale, high-magnification microscopic image of a porous, interconnected cellular or fibrous structure, resembling a honeycomb or sponge-like material. The text "Thank you" is centered over this image in a large, white, sans-serif font.

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