INTERNATIONAL SYMPOSIUM ON SUPERCONDUCTING, MAGNETIC & ENERGY MATERIALS

& PROGRAMME ABSTRACT BOOK

ISSM 2020

OCTOBER 6—7TH, 2020

International Symposium on SUPERCONDUCTING, MAGNETIC & ENERGY MATERIALS

Jointly Organised by :

SUPERCONDUCTING MATERIALS LABORATORY

GRADUATE SCHOOL OF SCIENCE & ENGINEERING

SHIBAURA INSTITUTE OF TECHNOLOGY, JAPAN

&

SUPERCONDUCTOR & THIN FILM LABORATORY

PHYSICS DEPARTMENT, FACULTY OF SCIENCE

UNIVERSITI PUTRA MALAYSIA

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Sitting from left : *Amirah Natasha Ishak, Aliah Nursyahirah Kamarudin, Nurul Auni Khalid, Nur Athirah Che Dzul-Kifli and Yap Siew Hong*

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Foreword from

PROF. DR. MURALIDHAR MIRYALA

CHAIRMAN
THE INTERNATIONAL SYMPOSIUM ON SUPERCONDUCTING MAGNETIC AND ENERGY MATERIALS (ISSM 2020)

Good Day and Greetings,

On behalf of the organising committee, it is our great pleasure to extend to you a warm welcome on the occasion of the International Symposium on Superconducting, Magnetic and Energy Materials (ISSM), to be held virtually on 06 & 07 October 2020. ISSM is jointly organised between the Superconducting Materials Laboratory, Shibaura Institute of Technology and Superconductor & Thin Film Laboratory, Universiti Putra Malaysia. The event is also co-organised and supported by Malaysian Solid State Science and Technology Society (MASS).

The 2-day symposium offers a remarkable opportunity for researchers from universities and industries to share their findings and exchange ideas in the related fields through oral presentation session. It also aims to serve as a platform to provide latest information and developments concerning superconductivity, magnetism and energy materials.

For all the speakers, thank you for accepting our invitation amidst your busy schedule. We are indeed honoured to have you with us in this symposium.

At this juncture, we would like to sincerely thank the organising committee for their endless effort and support in ensuring the symposium a successful event!

Thank you very much.

Prof. Dr. Muralidhar Miryala
Assoc. Prof. Dr. Chen Soo Kien

ASSOC. PROF. DR. CHEN SOO KIEN

CHAIRMAN
THE INTERNATIONAL SYMPOSIUM ON SUPERCONDUCTING, MAGNETIC AND ENERGY MATERIALS (ISSM 2020)

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PROGRAMME SCHEDULE

6th October 2020, Tuesday

0800 – 0830	Registration (at UPM only)
0830-0900	**OPENING CEREMONY** Welcome Speech from • **Prof. Dr. Masato Murakami**, *President of Shibaura Institute of Technology (SIT),* Japan • **Prof. Dr. Mohd Basyaruddin Abdul Rahman,** *Dean, Faculty of Science, Universiti Putra Malaysia (UPM)* • **Prof. Dr. Abdul Halim Shaari,** *President of Malaysian Solid State Science and Technology Society (MASS)*
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0930- 0955	**KEYNOTE SPEAKER I - Prof. Dato' Dr. Roslan Abdul Shukor (UKM)** Elastic Properties and Coherence Length of Superhydride Superconductors
0955 – 1020	**KEYNOTE SPEAKER II - Assoc. Prof. Dr. Kean Pah Lim (UPM)** Hole-Doped Manganites: A Spintronic Compound
1020 – 1040	BREAK
SESSION II : ORAL PRESENTATION CHAIRPERSON : ASSOC. PROF. DR. SOO KIEN CHEN	
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1100 – 1120	**Dr. Alicja Klimkowicz (SIT)** Oxygen Production and Storage Using Solids
1120 – 1140	**Dr. Kumkum Ahmed (SIT)** 3D Printable Functional Materials and Their Applications
1140 - 1200	**Dr. Sai Srikanth Arvapalli (SIT)** High Energy Ultra-sonication of Boron Powder for Low Cost and High-Performance Bulk MgB_2
1200 – 1330	LUNCH

SESSION III : KEYNOTE AND ORAL PRESENTATION CHAIRPERSON : ASSOC. PROF. DR. MOHD MUSTAFA AWANG KECHIK	
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1355 – 1415	**Dr. Durga Shankar (AU/SIT)** Multifunctional Brownmillerites for Energy and Environmental Applications
1415 – 1430	**Fatma Ali Alfirgani Barood (UPM)** Synthesis of Pure $YBa_2Cu_3O_{7-\delta}$ Ceramic by Thermal Treatment Method
1430 – 1445	**Lik Nguong Lau (UPM)** Effect of TiO_2 Nanoparticle Addition on the Structural, Magnetic, Electrical, and Magneto-Transport Properties of Sol-Gel Synthesised $La_{0.67}Ca_{0.33}MnO_3$ Composites
1445 – 1500	**Nurhidayah Binti Mohd Hapipi (UPM)** Influence of Heat Treatment on Superconducting Properties of *Ex-Situ* MgB_2 with Addition of Mg
1500 – 1515	**Nurul Auni Binti Khalid (UPM)** Significance of Zinc Ferrite Nanoparticles Addition on Transport and Superconducting Properties of Thallium-Based High Temperature Superconductor
1515 – 1530	**Siti Nabilah Binti Abdullah (UPM)** The Effect of Graphene Nanoparticle Addition on Bi-2223 Superconducting Properties Prepared via Co-Precipitation Method
1530 – 1545	**Amirah Natasha Binti Ishak (UPM)** Structural, Electrical and Magnetic Properties of Nd-Sr-Mn-O/CuO by Solid-State Reaction Method
1545 – 1600	**Nur Athirah Binti Che Dzul-Kifli (UPM)** Synthesis and Characterization of $YBa_2Cu_3O_7$ Superconductor by Thermal Treatment Method with Multiferroic Addition

PROGRAMME SCHEDULE

7th October 2020, Wednesday

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0925 – 0950	**KEYNOTE SPEAKER V - Prof. Tetsuo Oka (SIT)** Nickel Resource Recovery from Plating Waste Using an Intense Field of Superconducting Bulk Magnets
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1040 – 1100	**Dr. Reena Goyal (SIT)** Superconductivity in Layered $(Nb/Ta)_2Pd_x(S/Se/Te)_y$ Compounds
1100 – 1120	**Santosh Kumar (Oxford)** Superconductivity in Biomedicine: Enabling Next Generation's Medical Tools
1020 – 1135	**Muhammad Arash Bin Raees Ahmad (UPM)** Critical Current Density on $YBa_2Cu_3O_{7-x}$ with Er-211 Addition via Top Seed Melt Growth Technique (TSMG)

1135 – 1150	**Siew Hong Yap (UPM)** Comparative Study on XRD and AC Susceptibility of $Y_{0.85}K_{0.15}Ba_2Cu_3O_{7-\delta}$ and $Y_{0.85}Ca_{0.15}Ba_2Cu_3O_{7-\delta}$ Prepared via Thermal Treatment Method
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1325 – 1340	**Aliah Nursyahirah Binti Kamarudin (UPM)** Effect on Structural and Superconducting Properties of $YBa_2Cu_3O_{7-x}$ (Y123) Superconductor Added with Graphene Nanoparticles via Thermal Treatment Method
1340 – 1355	**Safia Izzati Binti Abd. Sukor (UPM)** Effect of Double Calcination on Synthesizing Bi-2223 by Using Thermal Treatment Methods
1355 – 1410	**Sushma M. (SIT/EIS)** Superconducting Performance of TSIG Processed $YBa_2Cu_3O_y$ Produced by $YBa_2Cu_3O_y$ + Liquid Phase as a Liquid Source
1410 – 1425	**Rahimah Mustapa Zahari (UPM)** Study of Structural, Magnetic and Microwave Absorption Properties of Y-substituted $BiFeO_3$ Ceramics Synthesized by Modified Thermal Treatment Method
1425 – 1440	**Sunsanee Pinmangkorn (SIT)** Flux Pinning and Superconducting Performance of Melt Grown Bulk $YBa_2Cu_2O_y$ via Ultrasonically Refined Y_2BaCuO_5
1440	CLOSING CEREMONY

ABSTRACTS

Plenary Speakers

Development of RE-123 Super-magnets Use in the Day Life Public

M. Muralidhar, A. Sai Srikanth, P. Sunsanee, G. Reena, T. Oka, N. Sakai and M. Murakami

Superconducting Materials Laboratory, Graduate School of Science and Engineering, Shibaura Institute of Technology 3-7-5 Toyosu, Koto-ku, Tokyo 135-8548, Japan

*miryala1@shibaura-it.ac.jp

Keywords: Sustainable development goals (SDG's), RE-123 Super-magnets

Abstract. The economic growths, world peace, future development of our globe requires the production of new materials that improve the quality of life. Superconductivity in general allows for 100% current transmission without losses. This proves to be a super valuable resource for sustainability in many aspects. The high-temperature superconducting materials (HTSC) will be crucial for day to life applications and more attractive for sustainable development goals (SDG's). In this talk, recent trends in high-T_c superconducting material low cost processing will be introduced and 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. Furthermore, I will summarize systematic developmental use of bulk superconducting materials in superconducting magnets. Now, one can be used up to 15 T at 77 K and high temperatures up to 90.2 K which will more attractive for several industrial applications.

Recent Research Development in Superconducting and Magnetic Materials at Superconductor and Thin Films Laboratory, UPM, Malaysia

*S. A. Halim, S. K. Chen, M. M. Awang Kechik, K. P. Lim and H. Baqiah

Department of Physics, Faculty of Science, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Phone: 03-97696647; Fax: 03-89454454

*ahalim@upm.edu.my

Keywords: *YBCO, BISCO, BiFeO3, CMR NSMO, NCMO*

Abstract. An overview of research activities and facilities at The Superconductor and Thin Films Laboratory, UPM, Malaysia are highlighted. The research areas explored include High Tc Superconductivity, Magnetoresistivity and Multiferroicity. The materials are in the form of bulk and thin films prepared via solid state sintering, thermal method with capping agent, sol-gel, co-precipitation, cryo-milling, spin coating, laser ablation and sputtering. Microstructure and surface morphology are observed using XRD, FESEM and AFM. The electrical and magnetic properties are studied using cryogenic four-point probe, Hall effect measurement system, Vibrating Sample Magnetometer, AC Susceptometer and Electro Spin Resonance. In this overview; some recent results of $YBa_2Cu_3O_7$ (Y123) and YBCO family; Bi-2223 and Bi-2212; $BiFeO_3$ nanoparticles, $BiFeO_3/Fe_2O_3$ composites and magnetoresistive ceramics (CMR) such as NSMO and NCMO micro/nanoparticles with various oxide addition are discussed. These materials provide a unique opportunity to study the physics of complex systems in which electrons, spins and phonons are strongly coupled.

ABSTRACTS

Keynote Speakers

Elastic Properties and Coherence Length of Superhydride Superconductors

R. Abd-Shukor*

Department of Applied Physics, Universiti Kebangsaan Malaysia

43600 Bangi, Selangor, Malaysia

*ras@ukm.edu.my

Keywords: hydride, superhydride based materials

Abstract. The discovery of near room temperature superconductivity in hydride and superhydride based materials under high pressure recently has opened up new avenues in the field of superconductivity. One of the important parameters of superconductors is the coherence length, ξ which is the variations of the density of superconducting phase. From the BCS theory, coherence length is related to the characteristic Cooper pair size. In this paper we discuss the relation between the transition temperature, T_c and ξ of heavy fermions, conventional, iron arsenide based, cuprate and superhydride near room temperature superconductors. In this paper we also calculated the discontinuity in the elastic moduli and longitudinal sound velocity at T_c of YH_6. This result showed the role of phonons in this hydride superconductor and the discontinuity value is within the range of most ultrasonic techniques. Our investigation also showed that the coherence length of a room temperature superconductor extrapolated from the existing data is around 10-15 Å. This is within the observed values in many superconductors including the cuprates and iron arsenide based materials.

Hole-doped Manganites: A Spintronics Compound

K.P. Lim[a*], L.N. Lau[b], A.N. Ishak[c], M.M. Awang Kechik[d], S.K. Chen[e] and S.A. Halim[f]

Superconductor and Thin Film Laboratory, Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

[*]limkp@upm.edu.my

Keywords: Manganites, Spintronic, Composite, LFMR

Abstract. Hole-doped manganites exhibit colossal magnetoresistance (CMR) have attracted huge research interest due to its potential application as magnetic sensing element. For a high efficiency element used in magnetic field sensing device, larger magnetoresistance (MR) at lower magnetic field is often desired. Extrinsic magnetoresistance or commonly known as low field magnetoresistance (LFMR) arises mainly due to grain boundary effect related to the natural or artificial grain boundary. When low magnetic field is applied, the originally disordered Mn spins will align, thus reducing the scattering and leading to an increase in MR. Previous work indicated that common approach to enhance the LFMR is by grain size reduction or introduction of a secondary phase at the manganites grain surface to create the spin-polarized tunneling effect. The effect of various types of oxide compound added to Pr/Nd-based manganites compound had been done to investigate its effect to the electrical and magnetic behavior of these composites. The physical properties such as magnetic and electrical behaviours of manganites are strongly depending on the particle size and/or distribution. Manganite compounds demonstrated here are possible to be applied as the magnetic sensor element.

Powder Technology for Enhancing Critical Current Density of MgB_2

*S. K. Chen, A. S. Halim, K. P. Lim and M. M. Awang Kechik

Department of Physics, Faculty of Science, University Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

*chensk@upm.edu.my

Keywords: MgB_2, superconductor

Abstract. Though magnesium diboride (MgB_2) has been discovered about twenty years ago, it is still being considered as a potential candidate among the various superconducting compounds for a wide range of application. Critical transition temperature, T_c of MgB_2 is a lot higher than that of the niobium-based superconductors. In comparison with the copper-oxide based high-T_c superconductors, grain coupling in MgB_2 is much stronger making it a weak-link free material. Nevertheless, more can be done to make MgB_2 competitive in terms of its critical parameters. In this talk, the role of powder technology in enhancing electromagnetic properties of MgB_2 is highlighted. In particular, strategies for enhancing critical current density, J_c of MgB_2 through powder processing are discussed.

Increased critical current density and pinning force in $YBa_2Cu_3O_{7-\delta}$ thin films by nano inclusions

M. M. Awang Kechik[1*], P. Mikheenko[2], D. Cardwell[3], N. H. Babu[3], J.S. Abell[2], I. A. Crisan[2], S.K. Chen[1], S.A. Halim[1], and K.P. Lim[1]

[1]Deparment of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Malaysia

[2]School of Metallurgy and Materials, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

[3]Department of Engineering, University of Cambridge, Trumpington Street, Cambridge CB2 1PZ, UK

*mmak@upm.edu.my

Keywords: $YBa_2Cu_3O_{7-\delta}$ thin films, $Gd_2Ba_4CuWO_y$ nano inclusions

Abstract. We have investigated the possibility of enhancing the flux pinning in $YBa_2Cu_3O_{7-\delta}$ thin films by using $Gd_2Ba_4CuWO_y$ nano inclusions. YBCO films were deposited on $SrTiO_3$ single crystal substrates by PLD using a scanning laser beam from a composite target having the composition $YBa_2Cu_3O_{7-\delta}$ + 1% mol $Gd_2Ba_4CuWO_y$ nano inclusions. The critical current density *J*c and the pinning force Fp, determined by DC magnetization measurements at temperatures of 77.3 K and in applied field up to 4.5 T, showed impressive increases in comparison with reference YBCO samples. Structural characteristics of the deposited films were investigated by using X-ray diffraction, scanning electron microscopy and atomic force microscopy. The films showed very good epitaxy, with the additional Gd2411 phase dispersed as nano inclusions with average dimensions of tens of nm. This enhancement of *J*c in high fields is due to the artificial pinning centres induced by the $Gd_2Ba_4CuWO_y$ nano-inclusions. However, as the film thickness increases above 1 μm, a significant reduction of *J*c was observed in all Gd2411 films which become even lower than the *J*c of the 0.96 μm-thick pure YBCO film. The magnitude of the *F*p max increases as the thickness decreases because of the contribution of the strong-pinning interface layer

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Nickel resource recovery from plating waste using an intense field of superconducting bulk magnets

T. Oka[1], K. Sudo[1], L. Dadiel[1], J. Ogawa[2], S. Fukui[2], T. Nakano[2], M. Ooizumi[2], M. Tsujimura[3], N. Sakai[1], M. Miryala[1], M. Murakami[1] and K. Yokoyama[4]

[1]Materials Science and Engineering, Shibaura Institute of Technology, 3-7-5 Toyosu, Koto-ku, Tokyo 135-8548, Japan

[2]Electric and Electronics Engineering, Niigata University, 5-50 Ikarashi-Ninoco, 950-8151 Niigata, Japan

[3]Aichi Giken Co., 50-1 Takeshita, Hitotsugi-Cho, Kariya, 448-0003 Aichi, Japan

[4]Electrical and Electronic Engineering, Ashikaga University, 268-1 Omae-Cho, Ashikaga, 326-8558 Tochigi, Japan

*okat@sic.shibaura-it.ac.jp

Keywords: Ni resource, $NiHPO_3$ precipitate

Abstract. A unique magnetic separation technique using the bulk magnets capable of generating intense field of several T has been introduces to recycle the Ni resource from the waste fluid of Ni-plating factories. Following the reformation from fine $NiHPO_3$ precipitate extracted from Ni-bearing waste, the $NiSO_4$ coarse crystals with weak magnetic susceptibility were collected on the magnetic pole emitting the magnetic field of more than 2 T. The data presenting the ratios of S and P elements estimated by ICP analysis showed us that two kinds of Ni-bearing precipitates were preferentially separated according to the ferromagnetic property. As for the industrial aspect, the amount of recycled $NiSO_4$ slurry as a raw material for plating process reached over 8 kg a day, showing that the magnetic separation technique using bulk magnets is applicable to the practical rare earth recycling.

SuperOx Japan: Recent Status of Production, Development and Application of 2G-HTS Wires

Sergey Lee*, Valery Petrykin, Naoyuki Hirata, Juhyun Chung, Miyuki Nakamura, Vladimir Vyatkin and Marat Guifulin

SuperOx Japan, SIC-3, 1880-2 Kamimizo, Chuo-ku, Sagamihara, Kanagawa 252-0243 Japan

* sergey@superox.co.jp

Keywords: 2G HTS wires, SuperOx

Abstract. In this presentation we overview the main results obtained since 2012 - the first year of commercial production of 2G HTS wires by SuperOx. Since that time our group produced and delivered hundreds kilometers of superconducting tapes with high degree of customization. In 2016-2017 we made a substantial progress in up-scaling of our production and installation of independent new high-throughput equipment in Japan and Russia. As a result, the wire production capacity was doubled and exceeded 100 km of 12 mm wide wire in 2018. Typical lengths of continuous pieces of finished wire that come out of production are 200-400m though reel-to-reel equipment at every stage on the wire fabrication route is capable of handling one- to a few kilometre-long pieces of tape.

The main directions for new product development in 2019-2020 were: (1) enhance wire performance in magnetic field, (2) use thinner (30-40 microns) substrate for higher engineering current density, (3) make narrow 1-2 mm wide tapes, (4) development of low-resistive and superconducting joints and (5) improvement of mechanical and delamination strength of wires.

As a result SuperOx has been developed the commercial product with the record high engineering current density Je which can be used for various application.

Currently SuperOx group involved in several joint R&D and commercial projects including development of advanced superconducting fault current limiters (SFCL), various coils for induction heaters and flywheels, motors for aircraft, magnets for fusion application etc.

ABSTRACTS

Presenters

Effect of Additions Titanium Oxide on Mechanical and Physical Properties of YBCO Superconductor by Co-precipitation Method

Arlina Ali[1, a, *], Mohd Mustafa Awang Kechik[2, b] and Abdul Halim Shaari[2, c]

[1]Universiti Malaysia Kelantan, Kampus Jeli Beg Berkunci No. 100, 17600, Jeli Kelantan, Malaysia

[2]Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

*arlina@umk.edu.my

Keywords: YBCO, Co-precipitation Method

Abstract. Yttrium barium copper oxide (YBa_2Cu_3O) is a superconductor material that have almost zero resistivity and behave as diamagnetic at trasition temperature. The purposes of this project were to evaluate the effect of TiO_2 on crystal structure of YBa_2Cu_3O and to investigate the influence on the physical and mechanical properties on YBa_2Cu_3O superconductor. The addition of TiO_2 were control at (0.00, 1.25, 2.50, 3.75 and 5.00) wt%. Moreover, the YBCO is synthesized by using co-precipitation. The evaluation was conducted by using BRUKER PHASER S2 for XRD analysis, JEOL JSM IT-100 scanning electron microscope for phase identification and Testometric M500-50CT Universal Testing Machine for compression testing. The overall crystal structure of YBCO retained at orthorhombic structure. The grain size of YBCO decreased as the amount of titanium oxide in YBCO increased. However, the overall compressive resistance of the YBCO decrease when the weight percentage of TiO_2 increased but the ductility increased as the weight percentage of TiO_2 increased. The additions of TiO2 increased on the mechanical properties but deceased the physical properties.

Oxygen production and storage using solids

Alicja Klimkowicz *

Shibaura Institute of Technology, Department of Engineering Science and Mechanics, 3-7-5 Toyosu, Koto-ku, 135-8548 Tokyo, Japan

Kanagawa University, Faculty of Engineering Department of Material and Life Chemistry Yokohama, Kanagawa 221-8686, Japan

* alicja@shibaura-it.ac.jp

Keywords: Oxygen production, TSA, PSA

Abstract. Oxygen production on a small scale can be achieved using temperature swing or pressure swing absorption methods (TSA and PSA). The efficiency of both technics heavily depends on the quality of the absorber materials used. The ideal candidates should have high oxygen capacity, the operation temperature needs to be possibly low, and the speed of the reaction should be fast. In this talk manganese-based, oxygen storage materials (OSM) will be evaluated in terms of their suitability for oxygen production using TSA and PSA methods as well as their oxygen storage ability.

3D Printable Functional Materials and Their Applications

Kumkum Ahmed[1]

[1]SIT Research Laboratory, College of Engineering, Innovative Global program, Shibaura institute of Technology

Keywords: 3D printing, additive manufacturing (AM), thiol-ene-based polymeric moiety

Abstract. In recent years, additive manufacturing (AM) or more widely known as 3D printing has accentuated among various research fields such as, education, designing, tissue engineering, electronics, microfluidics, MEMS, automotive, robotics and so on. Conjunction of a wide variety of functional material to this technology can boost the advancement of applied science and engineering field to a substantial extent. In this work, a series of 3D printable smart and intelligent materials like gels, composites and shape memory polymers will be demonstrated focusing on their potential applications in solid electrolytes, soft electronics and soft robotics. Several approaches have been made for the development of printable conductive gels and composites such as entrapping Ionic liquids Lithium ion in the thiol-ene-based polymeric moiety and in the acrylamide and polyvinylidene fluoride-based composite gels respectively; and incorporating carbon nanotubes in poly ionic liquid/polymethylmethacrylate-based conductive composites. Successfully utilization of a series of novel shape memory gels for 3D and 4D printing were also accomplished for prospective applications in soft robotics.

High Energy Ultra-sonication of Boron Powder for Low Cost and High-Performance Bulk MgB_2

S.S Arvapalli, M Miryala, S Pinmangkorn and M Murakami

Graduates School of Science and Engineering, Regional Environment System, Superconducting Material Laboratory, Shibaura Institute of Technology, 3-7-5 Toyosu, Koto-Ku, Tokyo 135-8548, Japan

*na17502@shibaura-it.ac.jp

Keywords: Ultrasonication, Cheap commercial boron, bulk MgB_2, Low cost processing.

Abstract. MgB_2 is the trending superconducting material because of its easy synthesis and commercial aspects, despite having low superconducting critical transition temperature (T_c ~ 39 K). However, it is necessary to improve the critical current density (J_c) for promoting this material for commercial use. It is known that in MgB_2 superconductor, the grain boundaries act as flux-pinning centres that enhance J_c. Hence, in this work, we tried to reduce the size of cheap commercial boron precursor powder using high energy ultra-sonication in ethanol media for various durations (15, 30, 45 and 60 minutes). The use of ultrasonically refined boron particles resulted in fine-grained MgB_2 matrix when sintered at 775 ^oC. XRD analysis showed that a high quality of MgB_2 with only small traces of MgO was formed. T_c close to 39 K was observed in all the bulks. While 36% improvement in J_c at 0T, 20 K was observed in MgB_2 bulk prepared with boron ultra-sonicated for 15 minutes. Microstructure studies showed that the refined boron particles start agglomerating with longer durations of ultrasonication that resulted in large MgB_2 grains in the bulk making 15 minutes the optimum ultrasonication duration. The present results demonstrate that the cost-effective performance improvement can be achieved in bulk MgB_2 without reduction in T_c via employing a cheap boron, refined by high-energy ultra-sonication.

Multifunctional Brownmillerites for Energy and Environmental Applications

Durga Sankar Vavilapalli*and Shubra Singh

Crystal Growth Centre, Anna University, Chennai - 600025, Tamil Nadu, India.

*v.durgasankar@yahoo.com

Keywords: Brownmillerite ($A_2B_2O_5$) multiferroic compounds, Ferroelectric photovoltaic (PV) applications, $BiFeO_3$

Abstract. In search of new and advanced materials for energy and environmental applications, we come across certain brownmillerite ($A_2B_2O_5$) multiferroic compounds, which are also called oxygen deficient perovskites (ABO_3). Oxygen vacancies and magnetic ordering in these compounds lead to possess smaller bandgap (less than 2eV) compared to regular perovskites. These materials are promising candidates for Ferroelectric photovoltaic (PV) applications, as it enhances the optical and electrical properties. A well-known multiferroic material, $BiFeO_3$, featuring relatively low solar cell efficiency (~7%) due to the relatively large band gap (2.6eV), has attracted much attention. In the present case we have developed several multifunctional brownmillerite compounds and these are promising materials for PV, photocatalytic and energy storage application. The optical and catalytic properties of these compounds make them potential photocatalysts for waste water treatment. Co-existence of transition metal-oxide active sites and oxygen vacancies in these brownmillerites is useful for efficient energy storage application. These studies point towards the role of multifunctional brownmillerites in the field of energy and environmental applications. The results will be presented in detail.

Synthesis of Pure $YBa_2Cu_3O_{7-\delta}$ ceramic by thermal treatment method

Fatma Ali Alfirgani Ahmed, Mohd Mustafa Awang Kechik*, Chen Soo Kien, Lim Kean Pah and Abdul Halim Shaari

Laboratory of Superconductor & Thin Films, Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

*mmak@upm.edu.my

Keywords: Thermal treatment method, YBCO superconductor, critical current density

Abstract. The preparation and characterization of $YBa_2Cu_3O_{7-\delta}$ bulk superconductors in oxygen atmosphere by thermal treatment method under is investigated in this study. In order to determine the properties of the sample, sample characterisation was done by using Thermogravimetric Analysis (TGA) to determine the melting point of precursor and bulk sample, X-ray Diffraction (XRD) to determine the phases obtained inside the sample, and Alternating Current Susceptibility (ACS) to measure the magnetisation of bulk sample for superconducting properties. XRD patterns showed that the orthorhombic Y-123 phase was successfully formed. Various superconducting parameter including critical temperature, T_c, intragranular critical current density, J_{cm} and higher Josephson's current I_0, were estimated from AC Susceptibility. The pure sample show only a single peak in χ'' and do not show the appearance of intra-granular loss peak. The onset transition temperature, ($T_{c\text{-}onset}$) shows the value of 91.7 K.

Effect of TiO_2 Nanoparticle Addition on the Structural, Magnetic, Electrical, and Magneto-transport Properties of Sol-gel Synthesised $La_{0.67}Ca_{0.33}MnO_3$ Composites

L.N. Lau, K.P. Lim[1]*, S.Y. Lai[1], M.M. Awang Kechik[1], S.K. Chen[1], N.B. Ibrahim[2] and S.A. Halim[1]

[1]Superconductor and Thin Film Laboratory, Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

[2]Department of Applied Physics, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor Darul Ehsan, Malaysia.

*limkp@upm.edu.my

Keywords: LCMO, Spintronic, Manganite Composite, Rietveld Refinement

Abstract. Colossal magnetoresistive (CMR) materials have been widely studied due to their huge potential in spintronic technology. An addition of secondary phase to the manganite composite capable to improve the low field magnetoresistance (LFMR). Structural, magnetic, electrical, and magneto-transport properties of (1-x) $La_{0.67}Ca_{0.33}MnO_3$ (LCMO): x TiO_2 composites, x = 0.00, 0.05, 0.10, 0.15 and 0.20 have been systematically investigated. Polycrystalline $La_{0.67}Ca_{0.33}MnO_3$ (LCMO) was synthesized via sol-gel method before appending with nanosized TiO_2. All samples are in LCMO dominant phase by having an orthorhombic structure (Pnma). The crystal structural parameters were studied by using Rietveld refinement. As the TiO_2 content increases, the magnetization is getting higher as observed via vibrating sample magnetometer (VSM) at room temperature. The MR (%) of the composite has been enhanced near the T_C with the content of secondary phase (TiO_2).

Influence of Heat Treatment on Superconducting Properties of *Ex-situ* MgB_2 With Addition of Mg

Nurhidayah Mohd Hapipi[a], Soo Kien Chen[a,b*], Muralidhar Miryala[c], Sai Srikanth Arvapalli[c], Masato Murakami[c], Abdul Halim Shaari[a,b], Mohd Mustafa Awang Kechik[a], Kean Pah Lim[a], Kar Ban Tan[d] and Oon Jew Lee[e]

[a]Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[b]Institute of Advanced Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[c]Graduate School of Science and Engineering, Regional Environment Systems, Superconducting Research Laboratory (SRL), Shibaura Institute of Technology, 3-7-5 Toyosu, Koto-ku, Tokyo 135-8548, Japan

[d]Department of Chemistry, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[e]Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

*chensk@upm.edu.my

Keywords: *ex-situ* MgB_2, sintering, Mg addition, superconducting transition, critical current density

Abstract. In this work, effects of heat treatment conditions on superconducting properties of *ex-situ* MgB_2 added with excess Mg (0.5 mol Mg) were investigated. The samples were prepared using solid-state reaction method. Sintering of the samples was carried out under argon gas flow from 700 °C to 1000 °C for 1 h. For sintering at 700 °C, the sintering time was varied from 1 h to 7 h. Analysis of the X-ray diffraction data showed that the samples were indexed to MgB_2 as the dominant phase with some minor peaks of MgO. Superconducting transition temperature, T_c of the samples did not change much (38.1 - 38.5 K). Addition of excess Mg into *ex-situ* MgB_2 increased self-field J_c (20 K) to 6.26 kA.cm^{-2} from 3.00 kA.cm^{-2} (pure *ex-situ* MgB_2) for the samples sintered at 700 °C for 1 h. As the sintering temperature was increased to 1000 °C, self-field J_c (20 K) of 39.83 kA.cm^{-2} was attained. The increment of J_c value is attributed to the improved grain coupling and enhanced grain boundary flux pinning.

Significance of zinc ferrite nanoparticles addition on transport and superconducting properties of Thallium-based high temperature superconductor

Nurul Auni Khalid[1], Mohd Mustafa Awang Kechik[2 *], Wei Kong[3], Chen Soo Kien[4], Abdul Halim Shaari[5] and Roslan Abd-Shukor[6]

[1, 2, 4, 5]Faculty of Science, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.

[3]Centre for Foundation and General Studies, Infrastructure University Kuala Lumpur, Jln Ikram-Uniten, 43000 Kajang, Selangor, Malaysia

[6]School of Applied Physics, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

[*]mmak@upm.edu.my

Keywords: Tl-1212; transport critical current density; $ZnFe_2O_4$ nanoparticles

Abstract. High temperature superconductor $(Tl_{0.85}Cr_{0.15})Sr_2CaCu_2O_{7-\delta}$ (Tl-1212) with addition of zinc ferrite ($ZnFe_2O_4$) nanoparticles were synthesized using high purity oxide powders through a solid state reaction method. $ZnFe_2O_4$ nanoparticles with composition of 0.01 wt.%, 0.02 wt.%, 0.05 wt.%, 0.10 wt.%, and 0.15 wt.% were added to the Tl-1212 superconductor. These Tl-1212 samples were characterized using scanning electron microscopy (SEM), powder X-ray diffraction method (XRD), energy dispersive X-Ray analysis (EDX), electrical resistance measurement, and transport critical current density measurement. All samples indicated Tl-1212 phase of a tetragonal structure with a secondary phase/impurity of CSCO. The transition temperatures ($T_{c\text{-}zero}$ *and* $T_{c\text{-}onset}$) were measured using a four-point probe method. The highest $T_{c\text{-}zero}$ recorded was 97 K, which was exhibited by the pure Tl-1212 sample. The onset critical temperature ($T_{c\text{-}onset}$) recorded was between 97 K and 105 K. The transport critical current density, J_c at 77 K was recorded by sample x = 0.05 wt. % at 13.16 A/cm^2. The introduction of $ZnFe_2O_4$ nanoparticles has enhanced T1-1212 superconductor's flux pinning effects and increased its transport critical current density (J_c).

The Effect of Graphene Nanoparticle Addition on Bi-2223 Superconducting Properties Prepared via Co-Precipitation Method

Siti Nabilah Abdullah, Mohd Mustafa Awang Kechik*, Abdul Halim Shaari, Chen Soo Kien, and Lim Kean Pah

Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

*mmak@upm.edu.my

Keywords: Co-precipitation, High – Tc, BSCCO, Single phase

Abstract. The effects of graphene addition into the superconducting properties of $(Bi_{1.6}Pb_{0.4})Sr_2Ca_2Cu_3O_{10}$ (Bi-2223) have been studied in this project. Series of addition with graphene nanoparticle were added into the samples with x = 0.0, 0.3, 0.5 and 1.0 wt% were synthesized using co-precipitation method. The samples were prepared by mixing bismuth acetate, lead acetate, strontium acetate, calcium acetate, and copper acetate powders with required weight ratio and mixed with acetate acid, propan-2-ol and oxalic acid. The samples were undergone calcination process at 730˚C for 12 hours and second calcination process at 845˚C for 24 hours. The calcined powder was pressed into pellets under pressure of 5 tonnes before sintered at 850˚C for 48 hours. In this research, the phase and the crystallographic structures of these samples were examined by x-ray diffraction (XRD). The critical temperatures, T_c of the samples were investigated by alternating current susceptometer. The XRD results showed that the most significant phase in the samples is BSCCCO 2223 superconducting phase, where it exhibits the tetragonal structure. However, there are another two extra phases, which are Bi-2212 phase and Ca_2PbO_4 phase detected in the samples. The weight percentage of phase formation of Bi-2223 were increased when samples were added with the graphene and the weight percentage of phase formation of Bi-2212 were decrease after added with the graphene. The crystallite for the samples slightly decreases when the sample was added with the graphene nanoparticle. The ac-susceptometer results showed that the Tc-onset decrease when the samples added with graphene, T_{cj} were decrease when added graphene and T_P which is coupling peak temperature decrease when the samples added with graphene. The susceptibility-temperature (χ'-T) and (χ"-T) curves of each samples were obtained and the critical temperature of the pure sample is observed.

Structural and Electrical Properties of Nd-Sr-Mn-O/CuO by Solid-state Reaction Method

A.N. Ishak, K.P. Lim*, L.N. Lau, M.M. Awang Kechik,
S.K. Chen, S.A. Halim and Y.X. Tneh

Superconductor and Thin Film Laboratory, Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

*limkp@upm.edu.my

Keywords: Manganites, NSMO, Solid-state reaction, Metal-insulator transition

Abstract. Colossal magnetoresistive (CMR) effect in perovskite manganites has been taken a lot of interests among researches especially in thin films and its potential application in magnetic sensing industrial for the past few years. In this research, $(1-x)Nd_{0.67}Sr_{0.33}MnO_3$ samples were prepared by adding xCuO where x = 0.00, 0.05, 0.10, 0.15 and 0.20 as the artificial barrier layer. Based on the previous research, it was proven that artificial barrier layer could enhance the extrinsic effect especially low-field magnetoresistance (LFMR). The $(1-x)Nd_{0.67}Sr_{0.33}MnO_3/xCuO$ composites were prepared using solid state reaction method. From the Thermogravimetric Analysis (TGA), NSMO phase was formed. Based on X-ray Diffraction (XRD) characterization, NSMO and CuO phases coexisted in the compound and did not react with each other. CuO acted as the artificial barrier layer and distributed on the surface of NSMO grains. Next, the electrical properties of the composites are measured using Four Point Probes (4PP) where the T_{MI} decreased as the CuO composition increased due to the double exchange (DE) mechanism that has been enhanced. CuO also acted as the insulating phase which caused the resistivity to increase. In conclusion, DE mechanism was dominant below T_{MI} value while Jahn-Teller (J-T) distortion took place above T_{MI} value which caused the resistivity to decrease as the temperature increased.

Synthesis and Characterization of $YBa_2Cu_3O_7$ Superconductor by Thermal Treatment Method with Multiferroic Addition

Nur Athirah Che Dzul-Kifli[1], Mohd Mustafa Awang Kechik[1*], Abdul Halim Shaari[1,2] Lim Kean Pah[1] and Chen Soo Kien[1,2]

[1]Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[2]Institute of Advanced Technology (ITMA), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

*mmak@upm.edu.my

Keywords: YBCO, superconductor, thermal treatment, Bismuth Ferrite

Abstract. Polycrystalline $YBa_2Cu_3O_7$ (Y-123) superconductor has been synthesized by using thermal treatment method. Superconductor samples were prepared based on metal nitrates as a starting material and polyvinyl pyrrolidone (PVP) as a capping agent. A high quality of bulk YBCO superconductor was prepared with the addition of the nano-particle Bismuth Ferrite, $BiFeO_3$ with different weight percentage of 0.2 wt.%, 1.0 wt.% and 1.5 wt.%, respectively. $BiFeO_3$ is a multiferroic material which exhibit both magnetic and ferroelectric order simultaneously. It becomes an attraction in electronics applications such as in data storage and quantum electromagnets. Consequently, the addition of $BiFeO_3$ can give multi source pinning centers and hence can enhance the properties of the superconductor. The characterization has been made for both the physical and electrical properties of the sample. The observation of the evolution of the microstructure, phase formation and resistivity measurement has been characterized by using Scanning Electron Microscope (SEM), X-Ray Diffraction (XRD) and AC Susceptibility (ACS). The phase analysis from XRD pattern for all samples indicated the majority Y-123 phase along with the minor Y-211 phase. However, a minor diffraction peak of BFO phase is only observed at 0.2 wt.%. The resistivity measurement on the onset critical temperature (T_c-$_{onset}$) is found to be the highest at the addition of 1.5 wt.%. As such, the introduction of BFOs improved the T_c significantly.

Distortion of Nodal Lines in the Superconducting Gap Symmetry of Organic Superconductor λ-$(BETS)_2GaCl_4$

Dita Puspita Sari[1,2,*], Retno Asih[1,2,♣], Koichi Hiraki[3], Takehito Nakano[4] , Yasuo Nozue[2], Adrian D. Hillier[5], Yasuyuki Ishii[5], and Isao Watanabe[1,2]

[1]Meson Science Laboratory, RIKEN Nishina Center, Wako, Saitama 351-0198, Japan,

[2]Department of Physics, Graduate School of Science, Osaka University, Osaka 560-0043, Japan,

[3]Department of Physics, School of Medicine, Fukushima Medical University, Fukushima 960-1295, Japan.

[4]Graduate School of Science and Engineering, Ibaraki University, Mito 310-8512, Japan.

[4]ISIS Facility, STFC Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, UK,

[5]Graduate School of Engineering and Science, Shibaura Institute of Technology, Saitama 337-8570, Japan

Keywords: organic superconductors, λ-$(BETS)_2GaCl_4$, anisotropy of spin

Abstract. The organic superconductors offer a unique opportunity to chemically engineer exotic superconducting states. Among these λ-$(BETS)_2GaCl_4$ (BETS = $(CH_2)_2S_2Se_2C_6Se_2S_2(CH_2)_2$) has been predicted to exhibit novel nodal gap symmetry. Our results show that the temperature dependence of the in-plane penetration depth, λ_{ac}, cannot be described by either an isotropic or a traditional nodal gap symmetry. A new analysis of the muon spin depolarisation has been developed to experimentally confirm that a theoretically predicted deformed nodal symmetry is achieved. From this, the absolute value of in-plane penetration depth, $\lambda_{ac}(0)$, was found to be 560(5) nm. The deformation of nodal lines is explained by the anisotropy of spin fluctuations between BETS dimers in the conducting plane.

Synthesis and Characterization of $YBa_2Cu_4O_8$ Superconductor Prepared Using $YBa_2Cu_3O_{7-x}$ and CuO via Solid State Reaction Technique with Heat Treatment at Ordinary Oxygen Pressure

Cheong Choon Min[1,2,*] and Chen Soo Kien[2,3]

[1]Centre for Engineering Programmes, Imperium International College, 3.01, Level 1-6, Kompleks Metro Pudu, Jalan Metro Pudu 2, Fraser Business Park, 55200 Kuala Lumpur, Malaysia.

[2]Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia

[3]Material Synthesis and Characterization Laboratory (MSCL), Institute of Advanced Technology, Universiti Putra Malaysia, 43400 Serdang Selangor, Malaysia

[*]cheong.cm@imperium.edu.my

Keywords: YBCO, Y-123, Y-124, superconductor, synthesis, solid state reaction, ordinary oxygen pressure.

Abstract. In this study, commercial $YBa_2Cu_3O_{7-x}$ and CuO powders were used to synthesize polycrystalline $YBa_2Cu_4O_8$ employing the conventional solid state reaction method with heating at 1 atm oxygen pressure. Sodium nitrate was used as catalytic enhancer during the chemical reaction. The samples were subjected to twice sintering at 815°C for 24 hours with intermittent grinding. Analysis of the x-ray diffraction (XRD) data showed that $YBa_2Cu_4O_8$ (Y-124) phase is dominance in the samples with the presence of $YBa_2Cu_3O_{7-x}$ (Y-123), and CuO as secondary phases. The four-point-probe method was used to measure superconducting transition temperature (T_c). The samples exhibited a dual transition with the onset of around T_c 77 K and 87 K, respectively. This is consistent with the co-existence of superconducting phase Y-124 and Y-123.

Superconductivity in layered $Nb_2Pd(S/Se)_5$ compounds

Reena Goyal[1], Muralidhar Miryala[1] and Masato Murakami[1]

[1]Superconducting Material Laboratory, Graduate School of Science and Engineering, Shibaura Institute of Technology, 3-7-5 Toyosu, Koto-ku, Tokyo 135-8548, Japan

Keywords: $(Nb/Ta)_2Pd_x(S/Se)_y$; magneto-transport measurements; Low-temperature heat capacity

Abstract. Here, the crystal structure and the physical properties of superconductors belong to $(Nb/Ta)_2Pd_x(S/Se)_y$ family are provided. Structurally, these superconductors (Nb_2PdS_5, Nb_2PdSe_5, Ta_2PdTe_6, Ta_2PdS_5) are crystallized in monoclinic structure with space group C2/m with slabs like laminar growth. High-field (140 kOe) magneto-transport measurements on these samples showed superconducting transition temperature, $T_c \sim 6$ K. The observed upper critical field (H_{c2}) of Nb_2PdSe_5, Ta_2PdTe_6 and Ta_2PdS_5 superconductors is within the Pauli paramagnetic limit ($H_{c2} = 1.84T_c$). Out of these superconductors, only Nb_2PdS_5 material is quite robust against magnetic field because interestingly, its upper critical field (H_{c2}) crosses Pauli paramagnetic limit by three times. Therefore, detailed studies on Nb_2PdS_5 superconductor have been carried out. Low-temperature heat capacity in superconducting state of Nb_2PdS_5 under different magnetic fields showed s-wave superconductivity with two different gaps. Two quasilinear slopes in Somerfield coefficient (γ) as a function of applied magnetic field and two-band behavior of the electronic heat capacity demonstrate that Nb_2PdS_5 is a multiband superconductor in weak coupling limit with $\Delta C/\gamma Tc = 0.9$, confirmed by the lower critical field (H_{c1}) measurements at various T below T_c.

Superconductivity in Biomedicine: Enabling Next Generation's Medical Tools

Santosh Miryala

Nuffield Department of Surgical Sciences, University of Oxford, Headington, Oxford, OX3 9DU

Keywords: biomedicine; bulk superconductors; superconducting cyclotrons

Abstract. As new technologies and scientific innovations emerge, superconducting materials are playing a phenomenal role in applications associated with healthcare and biomedicine. The magnificent properties of ideal magnetism, zero electrical resistance, and presence of quantized magnetic flux lines clearly indicate that superconductors are an attractive option for primary care and biomedical applications. The current superconducting research had proved its world-recognized strength in innovative magnet manufacture and design towards low and high temperature superconducting magnetic applications in healthcare systems; for instance, examples can include the significant role of superconducting magnets in diagnostic imaging where a successful clinical implementation of nuclear magnetic resonance and magnetic resonance imaging was conducted. On the other hand, compact superconducting cyclotrons are also playing an increasingly important role in medicine due to its emission of external beam therapy with carbon ions and protons. In the first section of this talk, an extensive overview of fundamental applications of superconductivity within biomedicine is discussed. Moreover, the second section of this talk primarily focuses on adopting models of thermally activated flux motion of magnetic field dependence numerous high performance bulk superconductors and optimizing its mathematical parameters for future biomedical applications.

Critical current density on $YBa_2Cu_3O_{7-x}$ with Er-211 addition via Top Seed Melt Growth Technique (TSMG)

Muhammad Arash Raees Ahmad[1], Mohd Mustafa Awang Kechik[1*], Muralidhar Miryala[2], Chen Soo Kien[2], Aima Ramli[2], Abdul Halim Shaari[1], Masato Murakami[2] and Sunsanee Pinmangkorn[3]

[1]Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Malaysia.
[2]Shibaura Institute of Technology, 3 Chome-7-5 Toyosu, Koto, Tokyo 135-8548, Japan.
[3]Department of Physics, School of Fundamental Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu Malaysia.

*mmak@upm.edu.my

Keywords: YBCO; Erbium-211; Superconductor; Top Seed Melt Growth

Abstract

We report the effect of different weight percentage of Er-211 on Y-123 superconductor. Five samples were prepared with x = 0, 10, 20, 30, 40 wt.% Er-211 by using top seed melt growth (TSMG). The current density (J_c) value exhibited were 22,400A/cm^2 at 77 K when 40 wt.% were added to Y-123 compared to 16,000A/cm^2 for pure sample. To support the legitimacy of this result, critical current temperature (T_c) and FE-SEM measurement were carried out. From T_c measurement we found that there was a drop of T_c value for 10, 20, 30 40 wt.% in comparison to pure sample. From this result we can conclude that Er-211 degrades the value of T_c but improves the J_c value up to 6000A/cm^2. Meanwhile for FE-SEM we can clearly see in every samples there were 211 embedded in Y-123 matrix which explains the changes of values in J_c and T_c. From the analysis of data obtained the major peak detected were Y-123 peaks which also possesses orthorhombic crystal structure that belongs to Pmmm group.

Comparative Study on XRD and AC Susceptibility of $Y_{0.85}K_{0.15}Ba_2Cu_3O_{7-\delta}$ and $Y_{0.85}Ca_{0.15}Ba_2Cu_3O_{7-\delta}$ Prepared via Thermal Treatment Method

Yap Siew Hong[1], Abdul Halim Shaari[1*] and Safia Izzati Abd Sukor

[1]Physics Department, Faculty Sciences, University Putra Malaysia, Malaysia

[*]ahalim@upm.edu.my

Keywords: Substitution, phase formation, crystal structure, onset critical temperature, hole concentration

Abstract. Comparative study on $YBa_2Cu_3O_{7-\delta}$ (YBCO) substitution with alkali metals (K and Ca) in Y site was carried out by a simple thermal treatment method. Three samples, YBCO, $Y_{1-x}K_xBaCuO$ and $Y_{1-x}Ca_xBaCuO$ (x=0.15) were sintered in atmosphere at 920°C for 24 hours. The crystal structure and phase formation of the samples were analyzed by X-Ray Diffraction (XRD). From XRD result, the $YBa_2Cu_3O_7$ (Y-123) substituted with K showed orthorhombic crystal structure with secondary phase $BaCuO_2$ beside a small amount of third phase (Y_2BaCuO_7) Y-211. However, for the case Ca substituted in Y-123, the phase of Y-211 was disappeared. AC Susceptibility (ACS) measurement showed onset critical temperature, $T_{c\text{-}onset}$ for YBCO is 92.24K. While, $T_{c\text{-}onset}$ for Ca substituted sample, 85.47K was found lower than K substituted sample, that is 92.04K. This is due to the reducing of oxygen content in the Cu-O chain in Ca substituted sample that led to the higher amount of hole concentration in the sample. In future, on-going research work shall be done by establishing structural relationship between the microstructure morphology and superconducting properties of the samples using Field Emission Scanning Electron Microscope (FESEM), Energy Dispersive X-Ray Spectroscopy (EDX) and Four Point Probe respectively. Moreover, this comparative study bring out the importance of alkali metals, K and Ca substitution in YBCO system / bulk rare earth based **(**$REBa_2Cu3O_y$ (RE = bulk rare earth)) High Temperature superconductors synthesized using thermal treatment method. The future study also can be carried out for different bulk rare earth based (RE=Nd, Sm, and Ho) with varies sintering temperature via thermal treatment method.

Effect on Structural and Superconducting Properties of $YBa_2Cu_3O_{7-x}$ (Y123) Superconductor Added with Graphene Nanoparticles via Thermal Treatment Method

Aliah Nursyahirah Kamarudin[1], Mohd Mustafa Awang Kechik[1*], Chen Soo Kien[1], Aima Ramli[2], Lim Kean Pah[1], and Abdul Halim Shaari[1]

[1]Department of Physics, Faculty of Science, Universiti Putra Malaysia,

43400 UPM Serdang, Malaysia

[2]Department of Physics, School of Fundamental Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia

*mmak@upm.edu.my

Keywords: Y123 superconductor, thermal treatment method, graphene oxide

Abstract. Development of high temperature superconductors (HTS) Y123 bulk in industrial applications were establish since years ago. One of the developments that attracted great attention nowadays are especially in transportations, superconductors cables and wires. In this study, $YBa_2Cu_3O_{7-\delta}$ (Y123) bulk superconductors were prepared by the thermal treatment method due to the promising way to develop high quality YBCO superconductors through the simplicity, low cost, relatively low reaction temperatures during the process. Y123 were added with graphene nanoparticles (x = 0.0 – 1.0) wt%). Samples then were characterized by X-ray diffraction (XRD) analysis, field-emission scanning electron microscopy (FESEM), energy dispersive X-ray spectroscopy (EDX) and alternating current susceptibility (ACS). It was found that Y123 confirmed that the majority phase in all the XRD pattern were orthorhombic crystal structure and P*mm* space group with secondary phases belonged to Y211. The highest T_c obtained was sample x = 0.5 wt% followed by x = 1.0 wt% with 92.88 K and 92.72 K respectively. From the microstructure analysis, the average grain sizes become significantly decrease until 4.754 µm at x = 0.5 wt%. The addition of graphene nanoparticles had disturbed the grain growth of Y123, affecting in the superconducting properties of the samples.

Effect of Double Calcination on Synthesizing Bi-2212 By Using Thermal Treatment Method

S.I Abd Sukor[1], M.M Awang Kechik[1,*], S.A Halim[1], K.P Lim[1] and S.K Chen[1,2] and A.H Fisol[1]

[1]Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Malaysia

[2]Institute of Advance Technology (ITMA), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Malaysia

[*]mmak@upm.edu.my

Keywords: Bismuth-Strontium-Calcium-Copper-Oxide (BSCCO), Bi-2223, High Temperature Superconductor (HTS), Thermal treatment

Abstract. Thermal treatment method was used to synthesized Bi-2223 from starting materials of metal nitrates, PVP, nitric acid and deionized water. The calcination step was studied as the superconductor undergo different step, single and double calcination. From the XRD the phase formation of Bi-2223 was investigated. From the XRD analysis dominant phase belong to Bi-2223 and Bi-2212 was found as a minor phase. XRD analysis for double calcination shows an increase in Bi-2223 phase compared to single calcination. The microstructure of BSCCO 2223 was studied and were found that the shape of the BSCCO was irregular and with no specific shape. Tc was shown increase slightly during double calcine.

Superconducting performance of TSIG melt processed $YBa_2Cu_3O_y$ produced by $YbBa_2Cu_3O_y$+Liquid Phase as a Liquid Source

Sushma Miryala[1,2*] and Masato Murakami[1]

[1]Superconducting Material Laboratory, Department of Material Science and Engineering, Shibaura Institute of Technology, 3-7-5 Toyosu, Koto-ku, Tokyo 135-8546, Japan

[2] EISB, Singena Agrahara Road, Via Huskur Road/A.P.M.C. Yard, Huskur P.O, Electronic City, Bengaluru

Keywords: single-grain top-seeded, IG processed, Yb-123+$Ba_3Cu_5O_8$

Abstract. The utilization of novel materials, high T_c superconductors in particular, is essential in order to pursue United Nations Sustainable Development Goals as well as increasing worldwide demand for clean and carbon-free electric power technologies. Superconducting magnets have proven to be beneficial in several real-life applications such as transportation, energy production, MRI, drug delivery system etc. To achieve high performance, it is crucial to develop uniform single grain IG processed bulk IG processed. In this talk, we are reporting magnetic and microstructural properties of a single-grain top-seeded IG processed Y-123 pellet of 20 mm in diameter and 6 mm in height, produced utilizing the liquid Yb-123+$Ba_3Cu_5O_8$ as liquid source. The grown samples indicate four clear facet lines extended from seed up to the sample edges. Magnetization measurements by SQUID magnetometer exhibit a sharp superconducting transition with $T_{c,onset}$ at 92.1 K. The trapped field experiments at liquid nitrogen temperature reached by field-cooling process confirmed single cones, reflecting single grain Y-123 material character. The superconducting transition temperature, critical current performance at 77 K, microstructure, and trapped field values will be discussed in terms of futuristic material towards industrial applications.

Structural, magnetic and microwave absorption properties of $BiFe_{1-x}Y_xO_3$ ceramics synthesized by modified thermal treatment method

Rahimah Mustapa Zahari [a], Abdul Halim Shaari [a,*], Zulkifly Abbas [a], Ismayadi Ismail [b], Hussein Baqiah [c], Lim Kean Pah [a], Chen Soo Kien [a] and Mohd Mustafa Awang Kechik [a]

[a]Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

[b]Institute of Advanced Technology (ITMA), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

[c]Shandong Key Laboratory of Biophysics, Institute of Biophysics, Dezhou University, No. 566 University Rd. West, Dezhou, Shandong, China.

*ahalim@upm.edu.my

Keywords: BiFeO, modified thermal treatment method

Abstract. $BiFe_{1-x}Y_xO_3$ with x = 0.0, 0.1, 0.2, 0.3, 0.4, and 0.5 ceramics were synthesized by modified thermal treatment method. The structural, magnetic, and microwave absorption properties of the ceramics were studied by X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), vibrating sample magnetometer (VSM), and professional network analyzer (PNA). XRD analysis indicates the phase transformation occurred in the Y-substituted BFO samples from rhombohedral R3c (x = 0.0-0.1) to orthorhombic Pnma (x = 0.2-0.4), and to cubic Fm-3m (x = 0.5). With the increase of Y-concentrations, the average grain size was decreased from 90 to 354 nm. VSM analysis indicates the saturation magnetization and remnant magnetization at x = 0.2 was enhanced with M_s about 3.95 emu/g and M_r about 1.21 emu/g. The microwave measurements at 1 mm thickness over 8–12 GHz demonstrate that the highest absorption properties occurred at x = 0.0 with a minimum value of reflection loss of about –5.25 dB.

Flux pinning and superconducting performance of melt grown bulk $YBa_2Cu_2O_y$ via ultrasonically refined Y_2BaCuO_5

S Pinmangkorn, M Miryala, S.S Arvapalli and M Murakami

Graduates School of Science and Engineering, Regional Environment System, Superconducting Material Laboratory, Shibaura Institute of Technology, 3-7-5 Toyosu, Koto-Ku, Tokyo 135-8548, Japan

*na18505@shibaura-it.ac.jp

Keywords: ultrasonication technique, top seeded melt growth, superconducting performance $YBa_2Cu_3O_y$ and $YBa_2Cu_3O_y$

Abstract. $REBa_2Cu_3O_y$ (RE123) bulk superconductor, where RE = Y, Nd, Gd, Er, etc., has a great potential for various practical applications such as magnetic devices, medical devices, etc. The superconducting performance of $REBa_2Cu_3O_y$ bulk superconductor can be dramatically improved by controlling the precursor secondary phase (RE_2BaCuO_5, RE211). That is, we increase the flux pinning by obtaining fine RE211 particles. In this work, we employed a cheap technique - Ultrasonication, to refine and control particles size of the RE211 powder, without compromising on quality. A constant power of 300 W and 20 kHz are employed to ultrasonicated the RE211 particles dispersed in the ethanol media for various durations such as 0, 20, 40, 60, 80 and 100 minutes. The particles subjected to ultrasonication showed refined Y211 and destroyed surficial features with shape edges. We successfully fabricated single grained $YBa_2Cu_3O_y$ (Y123) bulk (20mm diameter) via top seeded melt growth (TSMG) with optimizing heat pattern. Highest critical current density (J_c) and trapped field values measured at 77 K are observed in the bulk prepared with ultrasonically refined Y211 for 80 minutes. High trapped field of 0.42 T at 77 K was recorded 0.3 mm above the surface centre of the bulk and the self-field critical current density was around 47 and 85 kA/cm^2 at 77 K and 65 K (H//*c*-axis), respectively. The magnetization measurements exhibited a sharp superconducting transition with critical onset temperature ($T_{c,onset}$) around 91 K. The present results demonstrate that the improved performance of bulk Y123 made from ultrasonically refined Y-211 secondary phase particles via the low cost ultrasonication process.

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