

# Advances in Superconductivity

- Research in superconductive materials was stagnant for many years.
  - Everyone assumed  $T_{C,max}$  was about 23 K
  - Many theories said it was impossible to increase  $T_C$  beyond this value
- 1987- new materials were discovered with  $T_C > 30$  K
  - ceramics of form  $Ba_{1-x} K_x BiO_{3-y}$
  - Started enormous race
    - $Y Ba_2 Cu_3 O_{7-x}$        $T_C = 90$  K
    - $Tl_2 Ba_2 Ca_2 Cu_3 O_x$        $T_C = 122$  K
    - difficult to make since oxidation state is very important
- The major problem is that these ceramic materials are inherently brittle.



# Advances In Superconductivity

**AW Rasmussen**



## **Advances In Superconductivity:**

Advances in Superconductivity IV Hisao Hayakawa, Naoki Koshizuka, 2012-12-06 Five years have passed since the breakthrough in the critical temperature for superconductors. During this period many superconducting materials have been discovered and developed and our knowledge of the physical and other properties of oxide superconductors has deepened through extensive and intensive research. This knowledge has advanced superconductivity science and technology from the initial questioning stage to a more developed but still uncertain second stage where research activity in superconductivity now overlaps with fields of application. Generally speaking science resonates with technology. Science not only complements but also competes with or stimulates technology. New scientific knowledge has triggered the second technological research stage. Much progress has been made in the development of practical devices encouraging the application of superconductors in areas such as human levitation, a high speed levitated bearing, large current transforming leads and high frequency devices. This technological progress has increased our understanding of the science involved such as flux pinning and dynamics and anomalous long range superconducting interactions. At this important stage international cooperation and collaborative projects can effectively sustain aggressive research and development in order to advance superconductivity to the next stages. The ISS Symposium is expected to serve as a venue for increasing our knowledge of superconductivity and for exchanging visions for future research and applications through the presentation and discussion of the latest research results. These proceedings also aim to summarize annual progress in high T<sub>c</sub> superconductivity in all fields.

**Advances in Superconductivity IV** Hisao Hayakawa, Naoki Koshizuka, 1992-06-04 Five years have passed since the breakthrough in the critical temperature for superconductors. During this period many superconducting materials have been discovered and developed and our knowledge of the physical and other properties of oxide superconductors has deepened through extensive and intensive research. This knowledge has advanced superconductivity science and technology from the initial questioning stage to a more developed but still uncertain second stage where research activity in superconductivity now overlaps with fields of application. Generally speaking science resonates with technology. Science not only complements but also competes with or stimulates technology. New scientific knowledge has triggered the second technological research stage. Much progress has been made in the development of practical devices encouraging the application of superconductors in areas such as human levitation, a high speed levitated bearing, large current transforming leads and high frequency devices. This technological progress has increased our understanding of the science involved such as flux pinning and dynamics and anomalous long range superconducting interactions. At this important stage international cooperation and collaborative projects can effectively sustain aggressive research and development in order to advance superconductivity to the next stages. The ISS Symposium is expected to serve as a venue for increasing our knowledge of superconductivity and for exchanging visions for future research and applications through the presentation and discussion of the latest research results.

These proceedings also aim to summarize annual progress in high  $T_c$  superconductivity in all fields Advances in Superconductivity II Takehiko Ishiguro, Koji Kajimura, 2013-03-09 Since the First International Symposium on Superconductivity ISS 88 was held in Nagoya Japan in 1988 significant advances have been achieved in a wide range of high temperature superconductivity research Although the  $T_c$ s of recently discovered oxide superconductors still do not exceed the record high value of 125K reported before that meeting the enrichment in the variety of materials should prove useful to the investigation of the fundamental mechanism of superconductivity in these exotic materials The discovery of the n type superconducting oxides proved to oppose the previously held empirical fact that the charge carriers in all oxide superconductors were holes In addition optimization of the charge carrier density has been established as a technique to improve the superconducting properties of the previously known oxide materials Many new experimental and theoretical advances have been made in understanding both the fundamental and the applied aspects of high temperature superconductivity In this latter area various new processing techniques have been investigated and the critical current densities and other significant parameters of both bulk and thin film oxide superconductors are rapidly being improved At this exciting stage of research in high temperature superconductivity it is extremely important to provide an opportunity for researchers from industry academia government and other institutions around the world to freely exchange information and thus contribute to the further advancement of research **Recent Advances in Superconductivity Research** Christopher B. Taylor, 2013 The authors of this book present current research in the study of superconductivity Topics discussed in this compilation include the effects of non magnetic defects in hole doped cuprates deep cryogenic refrigeration by photons based on the phonon deficit effect in superconductors superconductivity driven by an anti polar electric phase in high temperature superconducting materials superconductive graphite intercalation compounds a superconducting magnetic field concentrator with nanodimensional branches and slits magnetic mechanisms of pairing in a strongly correlated electron system of copper oxides two non linear mechanisms of correlations between copper carriers in superconductivity and their microscopical descriptions three dimensionality of the critical state and variational methods for magnetically anisotropic superconductors theory of multi band superconductivity conserving approximation for the self energy of the  $t-U-V-J$  model beyond the Hartree Fock approximation and superconductivity as a consequence of an ordering of zero point oscillations in electron gas Advances in Superconductivity VI Toshizo Fujita, Yuh Shiohara, 2012-12-06 More than seven years have passed since the dramatic breakthrough in the critical temperature for superconductors During this period a host of new materials have been discovered and efforts have been stepped up in a variety of domains including device and systems applications commercialization and basic research on the properties of superconductive materials Recent progress in areas such as bulk single crystal production long scale wire and tape production flywheel and bearing applications and electronic device applications for thin films indicate that science and technology have been working hand in hand in this field as has

been the case in the research and development of semi conductors This interdisciplinary resonance will be certain to lead to further outstanding advances in the years to come It goes without saying that worldwide information exchange is the key to accelerating progress in superconductivity science and technology As in previous years the ISS 93 served as a venue where visions of future develop ments were shared in addition to presentations and extensive discussions on the most up to date research results I hope that the Proceedings contained in this volume will be consulted not only as a summary of the current state of the art in high Tc superconductivity but also as a stimulating source of ideas regarding future applications of superconductivity research

**Advances in Superconductivity VIII** Hisao Hayakawa, Youichi Enomoto, 2013-11-11 Since the discovery of superconductivity with trans1tton temperatures above 77 K concentrated research activities toward the exploration of practical applica tions of these materials have been carried out Currently a remarkable improve ment in superconducting properties has been achieved due to the fine optimization of fabrication processes and this has attracted industrial interest for future applications In the case of NdBa Cu 0 materials a new pinning mecha 2 3 7 nism was found which enhances the critical current under applied magnetic fields In single crystals of these materials oxygen control results in an increase in the growth rate The metalorganic chemical vapor deposition MOCVD film quality has been improved by using a new liquid raw material Simultaneously real demands from the viewpoint of the market start to be a motivation force es pecially in electronics application where some products are already being sold At the same time interesting physical properlies have been obtained from a new superconducting single crystal which has a layered perovskite structure without copper In addition various precision measurement techniques have confirmed the d wave mechanism and the existence of intrinsic Josephson junctions in single crystals These new phenomena challenge the existing theoretical models but also open the way for new applications These significant areas of progress in materials science have led high Tc super conductivity research into the next phase of activity while fundamental research continues to be very important I sincerely hope that this volume will give further impetus to this development

**Advances in Superconductivity** J. Deaver, B.S. Deaver, J. Ruvalds, 2013-06-29 The Advanced Study Institute on Advances in Superconductivity was held at the Ettore Majorana Centre for Scientific Culture in Erice Sicily during July 3 to July 15 1982 This Institute was the third course of the International School of Low Tempera ture Physics which was established at the Centre in 1977 with the guidance and inspiration of T Regge and A Zichichi The 1982 Course was centered on a topic which brought together fundamental basic research and the most recent promising technological applications Accordingly the participants represented a wide spectrum of industrial and government laboratories as well as universities from various countries The program of topics and speakers was developed with the advice of the Organizing Committee composed of H Frohlich T Regge B Stritzker and L Testardi This Institute emphasized recent developments in the science and technology of superconductivity A historical perspective was provided by H Frohlich whose lectures recall the earliest discoveries and theoretical attempts to understand superconductivity Ironically

his early suggestion of the electron phonon coupling as a key to superconductivity was met with initial widespread skepticism. Later the development of field theory methods for solid state physics problems and the evolution of the BCS theory has led to a seemingly unanimous consensus regarding the electron phonon mechanism as the predominant source of superconductivity in known materials. Experimental studies of superconductivity exemplify the strong interplay of science and technology in many ways.

*Advances in Superconductivity X* Kozo Osamura, Izumi Hirabayashi, 2013-11-11 The International Symposium on Superconductivity which has been held annually since 1988 is a forum for presenting the most up to date information about a broad range of research and development in superconductivity from fundamental aspects to applications. More than 10 years have passed since the discovery of oxide superconductors and since various developments of applications began. It may be said that the prospects for application of oxide superconductors recently have opened up. Great progress has been made toward practical use for example of the flywheel which uses bulk materials and the high performance cryo cooled magnet made of bismuth wire. These were the results of persistent efforts to develop materials from the viewpoint of materials science and engineering. Also important is the progress in comprehensive understanding of high temperature superconductivity. Unique electronic properties of cuprates such as the non Fermi liquid normal state spin charge separation spin gap and d wave symmetry were discussed at the symposium as were the unique electromagnetic properties resulting from the low dimensionality of cuprates. In the field of new superconductors many exotic materials have been discovered since 1986. A decade of work with cuprate superconductors is reviewed in this proceedings and several of the newest materials are presented. These papers will be instructive for many researchers and for students who are to enter this field.

*Advances in Superconductivity VI* Toshizo Fujita, Yuh Shiohara, 1994-05-04 More than seven years have passed since the dramatic breakthrough in the critical temperature for superconductors. During this period a host of new materials have been discovered and efforts have been stepped up in a variety of domains including device and systems applications, commercialization and basic research on the properties of superconductive materials. Recent progress in areas such as bulk single crystal production, long scale wire and tape production, flywheel and bearing applications and electronic device applications for thin films indicate that science and technology have been working hand in hand in this field as has been the case in the research and development of semi conductors. This interdisciplinary resonance will be certain to lead to further outstanding advances in the years to come. It goes without saying that worldwide information exchange is the key to accelerating progress in superconductivity science and technology. As in previous years the ISS 93 served as a venue where visions of future developments were shared in addition to presentations and extensive discussions on the most up to date research results. I hope that the Proceedings contained in this volume will be consulted not only as a summary of the current state of the art in high Tc superconductivity but also as a stimulating source of ideas regarding future applications of superconductivity research.

*Advances in Superconductivity III* Koji Kajimura, Hisao Hayakawa, 2012-12-06 Since the

discovery of high temperature superconductors many new materials have been invented In the last year several new materials were also discovered but their critical temperatures are still below 100K Precise physical and chemical work has made tremendous progress in the theoretical and experimental study of physical properties and carrier state characterizations The de Haas van Alphen effect measurement showed the existence of a Fermi surface in YBCO Flux dynamics is a well known new problem in which flux creep and irreversibility line features are especially important for a fundamental understanding of the critical current and flux pinning Flux pinning centers which are intentionally added using non superconducting precipitates neutrons and protons etc increase critical currents to practical levels The analysis of electric and magnetic properties are expected to reveal the pinning mechanism and also to further application development As for wires and bulks many melt like sintering techniques have improved the material performance of critical current densities A new seeding Quench Melt Growth technique enlarged crystal size and increased the repulsion force These melting processes in conjunction with a mechanical strength improvement have been effectively introduced into wire fabrication in order to realize kilometer range wires and will put the oxide wires to practical use Where thin film is concerned when many fabrication methods had been developed using the assistance effect of activated oxygen such as ozone and oxygen radicals a high current density of 106A cm at 77K was reported

**Advances in Superconductivity VI**  
Toshizo Fujita, Yuh Shiohara, 1994-05-04 More than seven years have passed since the dramatic breakthrough in the critical temperature for superconductors During this period a host of new materials have been discovered and efforts have been stepped up in a variety of domains including device and systems applications commercialization and basic research on the properties of superconductive materials Recent progress in areas such as bulk single crystal production long scale wire and tape production flywheel and bearing applications and electronic device applications for thin films indicate that science and technology have been working hand in hand in this field as has been the case in the research and development of semiconductors This interdisciplinary resonance will be certain to lead to further outstanding advances in the years to come It goes without saying that worldwide information exchange is the key to accelerating progress in superconductivity science and technology As in previous years the ISS 93 served as a venue where visions of future developments were shared in addition to presentations and extensive discussions on the most up to date research results I hope that the Proceedings contained in this volume will be consulted not only as a summary of the current state of the art in high T<sub>c</sub> superconductivity but also as a stimulating source of ideas regarding future applications of superconductivity research

Advances in Superconductivity XII  
T. Yamashita, K. Tanabe, 2013-11-11 The 12th International Symposium on Superconductivity was held in Morioka Japan October 17-19 1999 Convened annually since 1988 the symposium covers the whole field of superconductivity from fundamental physics and chemistry to a variety of applications At the 12th Symposium a mini symposium focusing on the two dimensionality of high temperature superconductors or the c axis transport and a session on

vortex physics were organized There were also many reports on the recent developments of YBCO based coated conductors both in the United States and in Japan AC losses of wires and tapes developments of bulk materials with strong flux pinning the recent progress in thin film and junction technologies and the demonstration of various electronics applications using SQUIDs microwave devices and single flux quantum SFQ digital devices This volume is a valuable resource for all those working in the field of superconductivity

**Advances in Superconductivity J.** Deaver, B. S. Deaver, J. Ruvalds, 2014-09-01

**Advances in Superconductivity VII** Kaoru Yamafuji, Tadataka Morishita, 2012-12-06 The field of high temperature superconductivity has encouraged an inter disciplinary approach to research It has required significant cooperation and collaboration among researchers each of whom has brought to it a rich variety of experience from many other fields Recently great improvements have been made in the quality of research The subject has matured and been launched into the next stage through the resonance between science and technology The current progress of materials processing and engineering in this field is analogous to that previously seen in the development of semiconductors These include the appearance of materials taking the place of YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> owing to their improved properties higher critical temperatures and stronger flux pinning in which rare earth ions with large radii La Nd Sm substitute for Y the development of technology enabling growth control on the nanometer scale and precise and reproducible measurements that can be used as rigorous tests of theoretical models which in turn are expected to lead to the development of new devices For further progress in high T research academics and technologists must pool their knowledge and experience I hope that this volume will promote that goal by providing the reader with the latest results of high temperature superconductor research and will stimulate further discussion and collaboration

Superconducting Materials A. Tampieri, G. Celotti, 2000 This volume consists of lectures highlighting fundamentals of advances in superconducting materials related technologies and applications Theory fundamental aspects advances in materials synthesis processing and properties are featured as well as current developments of superconducting components and devices Both HTC and LTC superconducting materials are discussed Several years after the discovery of high T<sub>c</sub> superconductivity and a multinational effort in its study this book collects the main results on the subject and presents a state of the art view of the correlations between crystal chemistry and physical properties

Advances in Superconductivity VII Kaoru Yamafuji, Tadataka Morishita, 1995-06-01 The Seventh International Symposium on Superconductivity brought together researchers at the forefront of all fields such as physics chemistry materials production engineering and electronic and electrical engineering once again underlining the interdisciplinary nature of high temperature superconductivity Speakers shared their latest findings in the fundamental physics and chemistry superconductors in the form of individual devices and systems This comprehensive volume will prove indispensable for all who are involved in high temperature superconductivity research

**Advances in Superconductivity IX** Sadao Nakajima, Masato Murakami, 1997-09 C axis Current I The 110 thick homoepitaxial film of 320 nm shows a very good surface

flatness which suggests the unique 110 atomic plane helps 2 A 1 1 OJ dimensional epitaxial growth of YBCO films and shows excellent high Tc The resultant 1 0 surface morphology of YBCO is quite different Q R 270 1 60 m 0 from the 110 heteroepitaxial films of similar 0 0 0 thickness 11 In the case of heteroepitaxy \_ 1 0 irrespective of c axis 12 or a axis oriented R 270 3 71 m 0 films 5 only thin films show flat surfaces g 0 0 Tc 92 3K which however give usually a degraded Tc due 1 0 v v I to lattice mismatching In conclusion we have 1 R 270 31 9 mO succeeded to grow high quality 11 0 YBCO YBCO film Tc 90 7 K 0 0 YBCO IIO 1 0 d YBCO thinfilms on 11 0 YBCO single crystal substrate Xt u 1 0 substra substrates with very flat surfaces and high Tc s R 270 40 1 m 0 0 0 LLLLL J LL t J L Tc 9LWO L L K LLLLL L I I L L J L L I J 50 100 150 200 250 300

0 ACKNOWLEDGMENTS Temperature K One of the authors T U would like to thank Fig Recent Advances in Superconductivity S. L. Kakani, C. Hemrajani, 1990 Advances in Superconductivity VI Toshizō Fujita, Yuh Shiohara, 1994

**Advances in Superconductivity** Koichi Kitazawa, Takehiko Ishiguro, 1989-02-05 Intense recent activity in the field of high temperature superconductivity both in Japan and in the rest of the world was discussed at the First International Symposium on Superconductivity held in Nagoya in August 1988 Current research and development efforts by major Japanese companies in the field of high temperature superconductivity are reported by leading company scientists to give an overview of the high level of activity in the area Progress in the development of new materials and recent theoretical work is reported both from Japanese and international researchers Contributions are organized by topic with such topics as crystal chemistry and electronic structure processing and microstructure tapes and thick films wires and coils and thin film processing and properties Future applications of superconductivity including magnetic levitation vehicles electronics based on Josephson junctions power delivery energy storage ship propulsion and magnetic resonance imaging are particularly stressed

## Decoding **Advances In Superconductivity**: Revealing the Captivating Potential of Verbal Expression

In a period characterized by interconnectedness and an insatiable thirst for knowledge, the captivating potential of verbal expression has emerged as a formidable force. Its capability to evoke sentiments, stimulate introspection, and incite profound transformations is genuinely awe-inspiring. Within the pages of "**Advances In Superconductivity**," a mesmerizing literary creation penned by a celebrated wordsmith, readers set about an enlightening odyssey, unraveling the intricate significance of language and its enduring impact on our lives. In this appraisal, we shall explore the book's central themes, evaluate its distinctive writing style, and gauge its pervasive influence on the hearts and minds of its readership.

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