Determination Of The Magnetic Penetration Depth In A

In 1987 a major breakthrough occurred in materials science. A new family of materials was discovered that became superconducting above the temperature at which nitrogen gas liquifies, namely, 77 K or –196°C. Within months of the discovery, a wide variety of experimental techniques were brought to bear in order to measure the properties of these materials and to gain an understanding of why they superconduct at such high temperatures. Among the techniques used were electromagnetic absorption in both the normal and the superconducting states. The measurements enabled the determination of a wide variety of properties, and in some instances led to the observation of new effects not seen by other measu- ments, such as the existence of weak-link microwave absorption at low dc magnetic fields. The number of different properties and the degree of detail that can be obtained from magnetic field- and temperature-dependent studies of electromagnetic abso- tion are not widely appreciated. For example, these measurements can provide information on the band gap, critical fields, the H–T irreversibility line, the amount of trapped flux, and even information about the symmetry of the wave function of the Cooper pairs. It is possible to use low dc magnetic field-induced absorption of microwaves with derivative detection to verify the presence of superconductivity in a matter of minutes, and the measurements are often more straightforward than others. For example, they do not require the physical contact with the sample that is necessary when using four-probe resistivity to detect superconductivity.

We present the magnetic penetration depth [lambda](T) in two laser ablated YBa[sub 2]Cu[sub 3]O[sub 7[minus][delta]] thin films, determined by the two-coil method. The slope of 1/[lambda][sup 2](T) near T[sub c], the only exactly measurable quantity, extrapolates to 930[Angstrom] at T=0, which compares well with 830[Angstrom] in the high quality single crystal recently reported by Hardy et al., and which exhibited a linear T dependence at low T. For T [lt] 30K, we find [lambda](T)/[lambda](0)[minus]1 = a(T/T[sub c])[sup 2] where a=0.5.

We present a way to reliably determine the field for first penetration H$_P$ in various kinds of bulk samples of niobium material used in the technical applications like fabrication of superconducting RF-cavities. Special attention is given to the role of flux line pinning in the determination of H$_P$. It is observed that the pinning properties and H$_P$ can change (or can be altered) significantly with the chemical treatment of bulk niobium. A correlation is proposed between H$_P$ of the niobium materials and the anomalous high-field Q-drop observed in the superconducting RF-cavities fabricated using such niobium material.

We present the magnetic penetration depth [lambda](T) in two laser ablated YBa2Cu3O{sub 7-{delta}} thin films, determined by the two-coil method. The slope of 1/[lambda]2(T) near T{sub c}, the only exactly measurable quantity, extrapolates to 930Å at T=0, which compares well with 830Å in the high quality single crystal recently reported by Hardy et al., and which exhibited a linear T dependence at low T. For T> 30K, we find [lambda](T)/[lambda](0)-1 = a(T/T{sub c})2 where a=0.5.

Common methods of local magnetic imaging display either a high spatial resolution and relatively poor field sensitivity (MFM, Lorentz microscopy), or a relatively high field sensitivity but limited spatial resolution (scanning SQUID microscopy). Since the magnetic field of a nanoparticle or nanostructure decays rapidly with distance from the structure, the achievable spatial resolution is ultimately limited by the probe-sample separation. This thesis presents a novel method for fabricating the smallest superconducting quantum interference device (SQUID) that resides on the apex of a very sharp tip. The nanoSQUID-on-tip displays a characteristic size down to 100 nm and a field sensitivity of 10^-3 Gauss/Hz^(1/2). A scanning SQUID microsope was constructed by gluing the nanoSQUID-on-tip to a quartz tuning-fork. This enabled the nanoSQUID to be scanned within nanometers of the sample surface, providing simultaneous images of sample topography and the magnetic field distribution. This microscope represents a significant improvement over the existing scanning SQUID techniques and is expected to be able to image the spin of a single electron.

Superconductivity is among the most fascinating properties that a material can have. Below the transition temperature T_c, electrons condensate into a macroscopic quantum mechanical state and flow without dissipation. The quantum nature of the superconducting state also manifests in its magnetic properties. Superconductors fully expels magnetic field in a weak applied field, referred as Meissner effect. In an intermediate field, superconductors often contain microscopic whirlpools of electrons that carry quantized magnetic flux, called vortices. In this thesis, I present magnetic-force-microscopy (MFM) studies of unconventional superconductors both in the Meissner state and in the mix state. We extend the application of MFM beyond the conventional imaging mode and use it for quantitative analysis. In the mix state, we use MFM manipulating individual vortices with a high level of control and a known force to study the mechanics and dynamics of a single vortex in cuprate superconductors. In the Messiner state, we establish MFM as a novel local technique to measure the magnetic penetration depth λ and implement it to study the pairing mechanism of iron-pnictide superconductors. Chapter 1 contains a brief introduction of MFM and its conventional application of imaging. We demonstrate high-spatial resolution images of isolated superconducting vortices. We show that by integrating images of isolated vortices at consecutive heights we are able to reconstruct the force between the MFM tip and vortices. We can also obtain the force by using a tip-vortex model. The two methods agree and both allow us to obtain the force used in vortex manipulation discussed in Chapter 2 and Chapter 3. Chapter 2 discusses the behavior of individual vortices in fully doped $YBa_2Cu_3O_{7-\delta}$ when subject to a local force. Because the anisotropy of fully doped $YBa_2Cu_3O_{7-\delta}$ is moderate, the vortex motion can be well described as an elastic string moving through a uniform three dimensional pinning landscape. We find an unexpected and marked enhancement of the response of a vortex to pulling when we wiggle it transversely. In addition, we find enhanced vortex pinning anisotropy that suggests clustering of oxygen vacancies in our sample. We demonstrate manipulation at the nanoscale with a level of control far beyond what has been reported before. We show that a dragged vortex can be used to probe deep into the bulk of the sample and to interact with microscopic structures much smaller than the tip size. Chapter 3 shows the vortex behavior in another limit. In an very underdoped $YBa_2Cu_3O_{6+x}$ single crystal, a cuprate superconductor with strong anisotropy, a vortex can be regarded as a stack of two-dimensional pancakes with weak interlayer Josephson coupling. We use the MFM tip to split the pancake stacks composing a single vortex and to produce a kinked structure. Our measurements highlight the discrete nature of stacks of pancake vortices in layered superconductors. We also measure the required force in the process, providing the first measurement of the interlayer coupling at the single vortex level. The discovery of iron-pnictide superconductors in 2008 motivates my efforts to locally measure the magnetic penetration depth λ, one of the two fundamental length scales in superconductors and known to be difficult to measure. Chapter 4 discusses the methodology of measuring λ by MFM, which is based on the time-reversed mirror approximation an analytical model of the MFM tip-superconductor interaction in the Meissner state. A calibration run was performed on \YBCO\ single crystals with known λ. The same time-reversed mirror approximation can be applied to scanning SQUID sysceptometry (SSS) to measure the temperature variation of penetration depth $\Delta\lambda(T)\equiv\lambda(T)-\lambda(0)$. Chapter 5 includes brief introduction of the iron-pnictide superconductors. The multiple conduction bands and the vicinity of the superconducting phase to magnetic phase give additional challenges in λ measurements. We demonstrated in this chapter on single crystals of Ba(Fe$_{0.95}$Co$_{0.05}$)$_2$As$_2$ that MFM can measure the absolute value of λ, as well as obtain its temperature dependence and spatial homogeneity. We observe that $\Delta\lambda(T)$ varies 20 times slower with temperature than previously reported by bulk techniques, and that $\rho_s(T)$ over the full temperature range is well described by a clean two-band fully gapped model, consistent with the proposed $s\pm$ pairing symmetry. Chapter 6 extends the measurements of $\rho_s(T)$ to the family Ba(Fe$_{1-x}$Co$_x$)$_2$As$_2$ with Co doping level x across the superconducting dome. We observe systematic evolution of $\rho_s(T)$ with x that can be summarized as three main trends. First, $\rho_s(0)$ falls more quickly with T_c on the underdoped side of the dome than on the overdoped. Second, the temperature variation of $\rho_s(T)$ at low temperature increases away from optimal doping. Third, $\rho_s(T)$ increases sharply with cooling through the superconducting transition temperature T_c of both optimally doped and underdoped compounds. These observations hint an interplay between magnetism and superconductivity.

This study examines the time-dependent penetration of a step increase in magnetic field strength H into a semi-infinite conducting medium having a permeability which varies with magnetic field strength. The medium is considered to be isotropic, homogeneous, and initially demagnetized. The medium at any point is presumed to follow its initial magnetization curve for which a simple approximation is assumed. The analytical approach consists of mathematical analysis supplemented with numerical calculations. The problem can be simplified from one involving a second order nonlinear partial differential equation to one involving a second order nonlinear ordinary differential equation utilizing a simple transformation of variables. Although a formal parametric representation of the solution of the second order differential equation is considered, a simple closed form solution in terms of elementary functions does not seem to exist. Hence several analytical techniques, as well as numerical calculations, have been employed to deduce properties of the solution.

Superconductivity is among the most fascinating properties that a material can have. Below the transition temperature T_c, electrons condensate into a macroscopic quantum mechanical state and flow without dissipation. The quantum nature of the superconducting state also manifests in its magnetic properties. Superconductors fully expels magnetic field in a weak applied field, referred as Meissner effect. In an intermediate field, superconductors often contain microscopic whirlpools of electrons that carry quantized magnetic flux, called vortices. In this thesis, I present magnetic-force-microscopy (MFM) studies of unconventional superconductors both in the Meissner state and in the mix state. We extend the application of MFM beyond the conventional imaging mode and use it for quantitative analysis. In the mix state, we use MFM manipulating individual vortices with a high level of control and a known force to study the mechanics and dynamics of a single vortex in cuprate superconductors. In the Messiner state, we establish MFM as a novel local technique to measure the magnetic penetration depth λ and implement it to study the pairing mechanism of iron-pnictide superconductors. Chapter 1 contains a brief introduction of MFM and its conventional application of imaging. We demonstrate high-spatial resolution images of isolated superconducting vortices. We show that by integrating images of isolated vortices at consecutive heights we are able to reconstruct the force between the MFM tip and vortices. We can also obtain the force by using a tip-vortex model. The two methods agree and both allow us to obtain the force used in vortex manipulation discussed in Chapter 2 and Chapter 3. Chapter 2 discusses the behavior of individual vortices in fully doped YBa$_2$Cu$_3$O$_{7-\delta}$ when subject to a local force. Because the anisotropy of fully doped YBa$_2$Cu$_3$O$_{7-\delta}$ is moderate, the vortex motion can be well described as an elastic string moving through a uniform three dimensional pinning landscape. We find an unexpected and marked enhancement of the response of a vortex to pulling when we wiggle it transversely. In addition, we find enhanced vortex pinning anisotropy that suggests clustering of oxygen vacancies in our sample. We demonstrate manipulation at the nanoscale with a level of control far beyond what has been reported before. We show that a dragged vortex can be used to probe deep into the bulk of the sample and to interact with microscopic structures much smaller than the tip size. Chapter 3 shows the vortex behavior in another limit. In an very underdoped YBa$_2$Cu$_3$O$_{6+x}$ single crystal, a cuprate superconductor with strong anisotropy, a vortex can be regarded as a stack of two-dimensional pancakes with weak interlayer Josephson coupling. We use the MFM tip to split the pancake stacks composing a single vortex and to produce a kinked structure. Our measurements highlight the discrete nature of stacks of pancake vortices in layered superconductors. We also measure the required force in the process, providing the first measurement of the interlayer coupling at the single vortex level. The discovery of iron-pnictide superconductors in 2008 motivates my efforts to locally measure the magnetic penetration depth λ, one of the two fundamental length scales in superconductors and known to be difficult to measure. Chapter 4 discusses the methodology of measuring λ by MFM, which is based on the time-reversed mirror approximation an analytical model of the MFM tip-superconductor interaction in the Meissner state. A calibration run was performed on \YBCO\ single crystals with known λ. The same time-reversed mirror approximation can be applied to scanning SQUID sysceptometry (SSS) to measure the temperature variation of penetration depth $\Delta\lambda(T)\equiv\lambda(T)-\lambda(0)$. Chapter 5 includes brief introduction of the iron-pnictide superconductors. The multiple conduction

Since the discovery in 1986 of high temperature superconductors by J. G. Bednorz and K. A. Müller, a considerable progress has been made and several important scientific problems have emerged. Within this NATO Advanced Study Institute our intention was to focus mainly on the controversial topic of the symmetry of the superconducting gap and given the very short coherence length, the role of fluctuations. The Institute on ‘The Gap Symmetry and Fluctuations in High- Superconductors’ took place in the “Institut d’Etudes Scientifiques de Cargèse” in Corsica, France, between 1 - 13 September 1997. The 110 participantsfrom 18 countries (yet 30 nationalities) including 23 full time lecturers, have spent two memorable weeks in this charming Mediterranean resort. All lecturers were asked to prepare pedagogical papers to clearly present the central physical idea behind specific model or experiment. The better understanding of physics of high temperature superconductivity is certainly needed to guide the development of applications of these materials in high and weak current devices.

This investigation analyzed lightning induced magnetic field penetration through protective metal screens using an equivalent magnetic dipole moment representation of an array of elliptic apertures. Two metal screens with differing aperture sizes were modeled. Experiments, using lightning level currents, measured the magnetic field penetration through each screen. A comparison of model versus experimental results was performed. The effect of decreasing mesh sizes on field penetration is also presented. The analysis used linear superposition to sum the contributions from the magnetic dipole moment equivalent of each screen aperture. A computer program was developed to the number of screen model. It allows the user to specify the number of screen apertures, their dimensions, and the exterior field angle across the screen. The results indicate that the model is accurate in predicting the interior magnetic field decay rate with distance from the screen and in accounting for the increased protection provided by decreasing mesh sizes. The only model inaccuracies are the overestimates for interior magnetic field strengths. The overall results indicate that an equivalent magnetic dipole moment representation can be used to model lightning induced magnetic field penetration through protective metal screens. (Thesis).

Determination of Magnetic Penetration Depth of High TC Superconductors from High Field Magnetization MeasurementsDetermination of the Magnetic Penetration Depth of the High Tc Superconductor YBa2Cu3O7-x by Polarised Neutron ReflectionMu SR Measurement of the Magnetic Penetration Depth in High-TC?Determination of the Temperature Dependence of the Penetration Depth of Nb in Nb/AlO3 Nb Josephson Junctions from a Resistive Measurement in a Magnetic Field

This volume will focus on the theory and experiments leading to quantitative understanding of the magnetic field and temperature dependence of critical current densities in high-temperature superconductors. Topics will include: critical currents and flux-pinning, flux flow and flux creep, anisotropy of critical fields and currents, properties of the flux lattice and the irreversibility line, magnetization, granularity. Contents:Critical Currents in Neutron Irradiated High Temperature Superconductors (H W Weber)Radiation Induced Disorder as a Unique Method for Studing Electronic States of HTSC's and Modifying Their Properties (B N Goshchitskii et al)Influence of Fast Neutron Irradiation on Various Types of HTSC Materials: Comprehensive Study (H Szymczak et al)Critical Currents and Angular Dependence in Magnetic a.c. Response: Test for Intrinsic Pinning (L Krusin-Elbaum et al)Why the Critical Current Densities of High Tc's Vary Anomalously with Temperature, Field and Time (S Senoussi et al)The Effect of the Intragranular Irreversible Magnetization on the Intergranular and Intragranular Critical Currents (S L Ginzburg et al)Bean-Livingstone Surface barrier in High Temperature Superconductors (M Konczykowski)Pinning Centers in C-Axis Oriented Bi-Sr-Ca-Cu-O Thin Films (G Jung et al)The Effect of an Electric Current on Microwave Absorption in a YBaCuO Ceramic Superconductor (J Stankowski et al)and other papers Readership: Condensed matter physicists, electronic and electrical engineers and chemists. keywords:

The temperature dependence of the penetration depth of Nb films was determined from resistive transitions of Nb/AlO(subscript x)/Nb Josephson junctions in a constant magnetic field applied parallel to the junction planes. Distinct resistance peaks were observed as temperature decreases and those peaks were found to appear when the total flux threading the junction equals an integral multiple of the flux quantum. From this condition, the authors have determined the penetration depth at those peak positions. The temperature dependence was well described by the either dirty local limit or the two-fluid model. This method can be useful for highly fluctuating system like high-temperature superconductors.

This book proposes a thorough introduction for a varied audience. The reader will master London theory and the Pippard equations, and go on to understand type I and type II superconductors (their thermodynamics, magnetic properties, vortex dynamics, current transport...), Cooper pairs and the results of BCS theory. By studying coherence and flux quantization he or she will be lead to the Josephson effect which, with the SQUID, is a good example of the applications. The reader can make up for any gaps in his knowledge with the use of the appendices, follow the logic behind each model, and assimilate completely the underlying concepts. Approximately 250 illustrations help in developing a thorough understanding. This volume is aimed towards masters and doctoral students, as well as advanced undergraduates, teachers and researchers at all levels coming from a broad range of subjects (chemistry, physics, mechanical and electrical engineering, materials science...). Engineers working in industry will have a useful introduction to other more applied or specialized material. Philippe Mangin is emeritus professor of physics at Mines Nancy Graduate School of Science, Engineering and Management of the University of Lorraine, and researcher at the Jean Lamour Institute in France. He is the former director of both the French neutron scattering facility, Léon Brillouin Laboratory in Orsay, and the Material Physics Laboratory in Nancy, and has taught superconductivity to a broad audience, in particular to engineering students. Rémi Kahn is a retired senior research scientist of the French Alternative Energies and Atomic Energy Commission (CEA-Saclay). He worked at the Léon Brillouin Laboratory and was in charge of the experimental areas of INB 101 (the Orphée research reactor). This work responded to the need to bring an accessible account suitable for a wide spectrum of scientists and engineers.

The International Symposium on Superconductivity, which has been held annu ally since 1988, is a forum for presenting the most up-to-date information about a broad range of research and development in superconductivity, from funda mental 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.

Neutrons can provide information on magnetic phenomena at surfaces. The simplest experiment involves the measurement of the reflectivity of a well-collimated beam from the surface, as a function either of the neutron wavelength or of the angle of incidence theta/sub i/. Using polarized neutrons, the spin-dependent reflectivity of a magnetically-active material can determine the depth profile of the magnetic induction B.A prototype instrument at the Intense Pulsed Neutron Source at Argonne has already demonstrated the feasibility of this technique in determining the penetration depth of an external magnetic field in superconductors. Further experiments are being planned to study the magnetic disturbances close to the surface of ferromagnets; a first experiment on films of iron oxides showed a remarkable change of the magnetic depth profile with increasing oxidation.

We present magnetic penetration depth measurements on various superconducting materials using a self-inductive, tunnel-diode based oscillator technique down to ?100 mK. The materials measured consisted of the skutterudites LaRu4Sb12 and LaOs4Sb 12, the heavy fermion superconductor CeIrIn5, a series of materials CeRh1-xIrxIn5, CeCoIn5 with two different dopants, Sn and Cd, and the layered dichalcogenide TiSe2 doped with copper. We seek to study the impact of antiferromagnetism and the presence of a quantum critical point on superconductivity. We also seek to characterize the superconductivity and compare to similar materials. Additionally we seek to study how superconductivity arises from novel methods such as charge density waves.

In this book the author presents two important findings revealed by high-precision magnetic penetration depth measurements in iron-based superconductors which exhibit high-transition temperature superconductivity up to 55 K: one is the fact that the superconducting gap structure in iron-based superconductors depends on a detailed electronic structure of individual materials, and the other is the first strong evidence for the presence of a quantum critical point (QCP) beneath the superconducting dome of iron-based superconductors. The magnetic penetration depth is a powerful probe to elucidate the superconducting gap structure which is intimately related to the pairing mechanism of superconductivity. The author discusses the possible gap structure of individual iron-based superconductors by comparing the gap structure obtained from the penetration depth measurements with theoretical predictions, indicating that the non-universal superconducting gap structure in iron-pnictides can be interpreted in the framework of A1g symmetry. This result imposes a strong constraint on the pairing mechanism of iron-based superconductors. The author also shows clear evidence for the quantum criticality inside the superconducting dome from the absolute zero-temperature penetration depth measurements as a function of chemical composition. A sharp peak of the penetration depth at a certain composition demonstrates pronounced quantum fluctuations associated with the QCP, which separates two distinct superconducting phases. This gives the first convincing signature of a second-order quantum phase transition deep inside the superconducting dome, which may address a key question on the general phase diagram of unconventional superconductivity in the vicinity of a QCP.

The temperature dependence of the penetration depth of Nb films was determined from resistive transitions of Nb/AlOx/Nb Josephson junctions in a constant magnetic field applied parallel to the junction planes. Distinct resistance peaks were observed as temperature decreases and those peaks were found to appear when the total flux threading the junction equals an integral multiple of the flux quantum. From this condition, the authors have determined the penetration depth at those peak positions. The temperature dependence was well described by the either dirty local limit or the two-fluid model. This method can be useful for highly fluctuating system like high-temperature superconductors.

Since the discovery of superconductivity, a great number of theoretical and experimental efforts have been made to describe this new phase of matter that emerged in many body systems. In this regard, theoretical models have been presented; the most famous of which was the BCS theory that can only describe conventional superconductors. With the discovery of new class superconductors, the superconducting mechanism became a new challenge in the field of condensed matter physics. This unexpected discovery opened a new area in the history of superconductivity, and experimental researchers started trying to find new compounds in this class of superconductors. These superconductors are often characterized by the anisotropic character in the superconducting gap function with nodes along a certain direction in the momentum space. Since the pairing interaction has an important role in the superconducting gap structure, its determination is very important to explain the basic pairing mechanism.In this regard, this book includes valuable theoretical and experimental discussions about the properties of superconductors. Here you will find valuable research describing the properties of unconventional superconductors.

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 discus of the latest research results. These proceedings also aim to summarize sion annual progress in high-Tc superconductivity in all fields.

All integrated optical components and devices make use of "waveguides", where light is confined by total internal reflection. The elements in such "photonic chip" are interconnected through waveguides, and also the integrated optics components themselves are fabricated using waveguide configuration, such as couplers, switches, modulators, multiplexors, amplifiers and lasers, etc. These components are integrated in a single substrate, thus resulting in a compact and robust photonic device, which can be optically connected through optical fibres. With and increase in the number of integrated optical components and devices emerging from the research laboratories to the market place an up-to-date book is essential in collecting, summarizing and presenting the new developed photonic devices. This includes fundamental aspects, technical aspects (such as fabrication techniques and materials) and characterisation and performance. This is an advanced text aimed at specialists in the field of photonics, but who may be new to the field of integrated photonics. The fundamental aspects have been carefully considered, and all the topics covered by the book start at a medium level, making it highly relevant for undergraduate and post-graduate students following this discipline.

Index to ASTM standards issued as last part of each vol.

This book deals with the theory and the applications of a new time domain, termed natural time domain, that has been forwarded by the authors almost a decade ago (P.A. Varotsos, N.V. Sarlis and E.S. Skordas, Practica of Athens Academy 76, 294-321, 2001; Physical Review E 66, 011902, 2002). In particular, it has been found that novel dynamical features hidden behind time series in complex systems can emerge upon analyzing them in this new time domain, which conforms to the desire to reduce uncertainty and extract signal information as much as possible. The analysis in natural time enables the study of the dynamical evolution of a complex system and identifies when the system enters a critical stage. Hence, natural time plays a key role in predicting impending catastrophic events in general. Relevant examples of data analysis in this new time domain have been published during the last decade in a large variety of fields, e.g., Earth Sciences, Biology and Physics. The book explains in detail a series of such examples including the identification of the sudden cardiac death risk in Cardiology, the recognition of electric signals that precede earthquakes, the determination of the time of an impending major mainshock in Seismology, and the analysis of the avalanches of the penetration of magnetic flux into thin films of type II superconductors in Condensed Matter Physics. In general, this book is concerned with the time-series analysis of signals emitted from complex systems by means of the new time domain and provides advanced students and research workers in diverse fields with a sound grounding in the fundamentals of current research work on detecting (long-range) correlations in complex time series. Furthermore, the modern techniques of Statistical Physics in time series analysis, for example Hurst analysis, the detrended fluctuation analysis, the wavelet transform etc., are presented along with their advantages when natural time domain is employed.

To use materials effectively, their composition, degree of perfection, physical and mechanical characteristics, and microstructure must be accurately determined. This concise encyclopledia covers the wide range of characterization techniques necessary to achieve this. Articles included are not only concerned with the characterization techniques of specific materials such as polymers, metals, ceramics and semiconductors but also techniques which can be applied to materials in general. The techniques described cover bulk methods, and also a number of specific methods to study the topography and composition of surface and near-surface regions. These techniques range from the well-established and traditional to the very latest including: atomic force microscopy; confocal optical microscopy; gamma ray diffractometry; thermal wave imaging; x-ray diffraction and time-resolved techniques. This unique concise encyclopedia comprises 116 articles by leading experts in the field from around the world to create the ideal guide for materials scientists, chemists and engineers involved with any aspect of materials characterization. With over 540 illustrations, extensive cross-referencing, approximately 900 references, and a detailed index, this concise encyclopedia will be a valuable asset to any materials science collection.

Proceedings of the Office of Naval Research Workshop on [title], held May 1991, in Coolfont, West Virginia, intended for experienced scientists new to the field and graduate students beginning their research. Contributors were asked to provide more experimental and theoretical detail than is generally found in the literature. Coverage includes basic experimental techniques and concepts, theoretical considerations and phenomenological models, bulk and single crystal examples, thin films, magnetically ordered and spin- glass systems, and specialized measuring techniques, along with remarks on the irreversibility line. Annotation copyrighted by Book News, Inc., Portland, OR

"This comprehensive reference covers all the important aspects of heat exchangers (HEs)--their design and modes of operation--and practical, large-scale applications in process, power, petroleum, transport, air conditioning, refrigeration, cryogenics, heat recovery, energy, and other industries. Reflecting the author's extensive practical experienc