



Dielectric properties of ZnO/ZnNb₂O₆ composite for energy storage applications

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Graphical Abstract

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Abstract.

In this paper, the dielectric properties of synthesized ZnO/ZnNb₂O₆ composite were investigated. The solid-state synthesis method was used. Then the elaborated composite was characterized using X-ray diffraction and impedance spectroscopy. The XRD patterns confirm the co-existence of a hexagonal ZnO and an orthorhombic ZnNb₂O₆ phases. Then, the dielectric properties were investigated at room temperature (RT) in a wide range of frequencies (from 20 Hz to 1MHz). The composite Nyquist curve revealed the grain and grain-boundaries contributions. Indeed, theoretical fit evidenced high resistance, and low dielectric losses simultaneously with capacitive behavior of the composite. So this composite is promising to be used in super capacitor for energy storage applications.

Introduction

Energy storage will be more important in the future than at any time in the past. Thus, lithium batteries are one of the most useful material in this domain [1]. But this material had many inconvenient: pollutant, high cost. So we have to search new sources that are more efficient and more secure. In this topic, we are interested to the ZnO/ZnNb₂O₆ composite that can be used in this application thanks to the interesting properties of the ZnO and ZnNb₂O₆. In fact, the columbite (ZnNb₂O₆) has interesting properties: low cost [1], good dielectric properties [2] and its suitability to numerous applications such as microwave dielectric ceramics [3], gas sensing [4], photocatalytic applications [5]. This work is focused on ZnO/ZnNb₂O₆ composite prepared using solid state method. XRD data are analysed to identify the crystal phases. Then, Dielectric spectroscopy was used to investigate the dielectric properties of the composite. Theoretical models were used to fit the experimental data.

Materials and Methods

The powder of ZnO/ ZnNb₂O₆ composite was prepared by a solid state method. 1 mol.% Nb₂O₅ was added to 99mol.% ZnO powder. ZnO and Nb₂O₅ powders were provided by Sigma Aldrich. Then, the mixture was milled then calcinated (400 °C, 4 hours). After that, the mixed powder was milled for a second time then pressed into pellets (1 mm thickness, 8 mm diameter). Then, the pellets were sintered (900°C, 24 hours). Finally, the pellets were milled for a last time to obtain the ZnO/ZnNb₂O₆ composite powder. The structural data were investigated by an X-ray diffractometer (Panalytical X Pert PRO MPD) with CuK_α radiation ($\lambda = 1.5406 \text{ \AA}$), 2θ varying from 20° to 80°. Dielectric measurements were carried out using dielectric spectroscopy (Hewlett Packard 4284A LCR meter) from 20 Hz to 1MHz at room temperature (RT).

Results and Discussion

The XRD patterns (fig.1) evidenced the presence of two phases; ZnO and ZnNb₂O₆ with hexagonal (P6₃mc) and orthorhombic (Pbcn) structures, according to JCPDS files:(96-210-7060) and (31-5041) respectively. The sharpness of diffraction peaks

proves the good crystalline quality of the prepared powder. Fig.2 shows experimental and theoretical adjustment of the Nyquist plots of ZnO and ZnO/ZnNb₂O₆ composite, according to equations (2) and (3). It displays non-Debye type relaxation shape. Indeed, as noticed, the experimental data of composite

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Temperature Measurement Metrology in Medicine **Microwave Materials and Applications, 2 Volume Set** Mailadil T. Sebastian, Rick Ubic, Heli Jantunen, 2017-05-08 Die jüngsten Fortschritte im Bereich der drahtlosen Telekommunikation und dem Internet der Dinge sorgen bei drahtlosen Systemen beim Satellitenfernsehen und bei intelligenten Transportsystemen der 5. Generation für eine höhere Nachfrage nach dielektrischen Materialien und modernen Fertigungstechniken. Diese Materialien bieten ausgezeichnete elektrische, dielektrische und thermische Eigenschaften und verfügen über enormes Potenzial vor allem bei der drahtlosen Kommunikation bei flexibler Elektronik und gedruckter Elektronik. **Microwave Materials and Applications** erläutert die herkömmlichen Methoden zur Messung der dielektrischen Eigenschaften im Mikrowellenbereich, die verschiedenen Ansätze zur Lösung von Problemen der Materialchemie und von Kristallstrukturen in den Bereichen Doping, Substitution und Aufbau von Verbundwerkstoffen. Besonderer Schwerpunkt liegt auf Verarbeitungstechniken, Einflüssen der Morphologie und der Anwendung von Materialien in der Mikrowellentechnik. Gleichzeitig werden viele der jüngsten Forschungserkenntnisse bei Mikrowellen, Dielektrika und Anwendungen zusammengefasst. Die verschiedenen Kapitel untersuchen Oxidkeramiken für dielektrische Resonatoren und Substrate, HTCC, LTCC und ULTCC, Binder für Substrate, Polymer, Keramik, Verbundstoffe für Leiterplatten, Elastomer, Keramik, Verbundstoffe für flexible Elektronik, dielektrische Tinten, Materialien für die EMV-Abschirmung, Mikrowellen, Ferrite. Ein umfassender Anhang präsentiert die grundlegenden Eigenschaften von mehr als 4000 verlustarmen dielektrischen Keramiken, deren Zusammensetzung, kristalline Struktur und dielektrischen Eigenschaften für Mikrowellenanwendungen. **Microwave Materials and Applications** wirft einen Blick auf sämtliche Aspekte von Mikrowellenmaterialien und -anwendungen. Ein nützliches Handbuch für Wissenschaftler, Unternehmen, Ingenieure und Studenten, die sich mit heutigen und neuen Anwendungen in den Bereichen drahtlose Kommunikation und Unterhaltungselektronik beschäftigen. **Conference Proceedings**, 2006

Conference Record of the ... IEEE International Symposium on Electrical Insulation, 1998 **RF and Microwave Circuit Design** Charles E. Free, Colin S. Aitchison, 2021-09-03 **RF and Microwave Circuit Design** Provides up to date coverage of the fundamentals of high frequency microwave technology written by two leading voices in the field. **RF and Microwave Circuit Design: Theory and Applications** is an authoritative, highly practical introduction to basic RF and microwave circuits. With an emphasis on real world examples, the text explains how distributed circuits using microstrip and other planar transmission lines can be designed and fabricated for use in modern high frequency passive and active circuits and sub systems. The authors provide clear and accurate guidance on each essential aspect of circuit design, from the theory of transmission lines to the passive and active circuits that form the basis of modern high frequency circuits and sub systems. Assuming a basic grasp of electronic concepts, the book is organized around first principles and includes an extensive set of worked examples to guide student readers with no prior grounding in the subject of high frequency microwave technology. Throughout the text, detailed coverage of practical design using distributed circuits demonstrates the influence of modern

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Proceedings of 3rd International Conference on Machine Learning, Advances in Computing, Renewable Energy and Communication Anuradha Tomar,Hasmat Malik,Pramod Kumar,Atif Iqbal,2022-09-17 This book gathers selected papers presented at International Conference on Machine Learning Advances in Computing Renewable Energy and Communication MARC 2021 held in Krishna Engineering College Ghaziabad India during 10 11 December 2021 This book discusses key concepts challenges and potential solutions in connection with established and emerging topics in advanced computing renewable energy and network communications *Emerging Trends in Mobile Robotics* Hideo Fujimoto,Mohammad Osman Tokhi,2010 This book provides state of the art scientific and engineering research findings and developments in the area of mobile robotics and associated support technologies The book contains peer reviewed articles presented at the CLAWAR 2010 conference Robots are no longer confined to industrial manufacturing environments A great deal of interest is invested in the use of robots outside the factory environment The CLAWAR conference series established as a high profile international event acts as a platform for dissemination of research and development findings and supports such a trend to address the current interest in mobile robotics to meet the needs of mankind in various sectors of the society These include personal care public health and services in the domestic public and industrial environments The editors of the book have extensive research experience and publications in the area of robotics in general and in mobile robotics specifically and their experience is reflected in editing the contents of the book 日本ロボット学会誌 (Japan),1900

Proceedings of the 21st International Symposium on High Voltage Engineering Bálint Németh,2019-11-27 High voltage engineering is extremely important for the reliable design safe manufacture and operation of electric devices equipment and electric power systems The 21st International Symposium on High Voltage Engineering organized by the 90 years old Budapest School of High Voltage Engineering provides an excellent forum to present results advances and discussions

among engineers researchers and scientists and share ideas knowledge and expertise on high voltage engineering The proceedings of the conference presents the state of the art technology of the field The content is simultaneously aiming to help practicing engineers to be able to implement based on the papers and researchers to link and further develop ideas

Polymer Insulation Applied for HVDC Transmission Boxue Du,2020-12-15 This book focuses on polymer insulation as applied to HVDC transmission It addresses both fundamental principles and engineering practice with more weight placed on the latter This is achieved by providing in depth studies on a number of major topics such as DC insulation structure DC insulation design nanocomposites modification testing and performance evaluation In turn several typical HVDC insulation application cases are examined in detail e g cables cable accessories GIS GIL and converter transformers A comprehensive and systematic study on polymer insulation modification and ageing assessment is one of the book s major features making it particularly well suited for readers who are interested in learning about polymer insulation materials Given its scope it offers a valuable resource for researchers engineers and graduate students in the fields of high voltage and insulation technologies electrical engineering material engineering etc

Ultra-Wideband Radio Technologies for Communications, Localization and Sensor Applications Reiner Thomä,Reinhard Knöchel,Juergen Sachs,Ingolf Willms,Thomas Zwick,2013-03-13 Ultra Wideband Radio UWB earmarks a new radio access philosophy and exploits several GHz of bandwidth It promises high data rate communication over short distances as well as innovative radar sensing and localization applications with unprecedented resolution Fields of application may be found among others in industry civil engineering surveillance and exploration for security and safety measures and even for medicine The book considers the basics and algorithms as well as hardware and application issues in the field of UWB radio technology for communications localization and sensing based on the outcome of DFG s priority funding program Ultra Wideband Radio Technologies for Communications Localization and Sensor Applications UKoLoS

Recent Trends in the Condition Monitoring of Transformers Sivaji Chakravorti,Debangshu Dey,Biswendu Chatterjee,2013-10-21 Recent Trends in the Condition Monitoring of Transformers reflects the current interest in replacing traditional techniques used in power transformer condition monitoring with non invasive measures such as polarization depolarization current measurement recovery voltage measurement frequency domain spectroscopy and frequency response analysis The book stresses the importance of scrutinizing the condition of transformer insulation which may fail under present day conditions of intensive use with the resulting degradation of dielectric properties causing functional failure of the transformer The text shows the reader how to overcome the key challenges facing today s maintenance policies namely The selection of appropriate techniques for dealing with each type of failure process accounting for the needs of plant owners plant users and wider society and Cost efficiency and durability of effect Many of the failure management methods presented rely on the fact that most failures give warning when they are imminent These potential failures give rise to identifiable physical conditions and the novel approaches described detect them so that action can be

taken to avoid degeneration into full blown functional failure This on condition maintenance means that equipment can be left in service as long as a specified set of performance standards continue to be met avoiding the costly downtime imposed by routine and perhaps unnecessary maintenance but without risking equally expensive failure Recent Trends in the Condition Monitoring of Transformers will be of considerable interest to both academic researchers in power systems and to engineers working in the power generation and distribution industry showing how new and more efficient methods of fault diagnosis and condition management can increase transformer efficiency and cut costs Practical Partial Discharge Measurement on Electrical Equipment Greg C. Stone,Andrea Cavallini,Glenn Behrmann,Claudio Angelo Serafino,2023-08-28 Practical Partial Discharge Measurement on Electrical Equipment Accessible reference dealing with partial discharge PD measurement in all types of high voltage equipment using modern digital PD detectors Practical Partial Discharge Measurement on Electrical Equipment is a timely update in the field of partial discharges PD covering both holistic concepts and specific modern applications in one volume The first half of the book educates the reader on what PD is and the general principles of how it is measured and interpreted The second half of the book is similar to a handbook with a chapter devoted to PD measurements in each type of high voltage HV equipment These chapters contain specific information of the insulation system design causes of PD in that equipment off line and on line measurement methods interpretation methods and relevant standards The work is authored by four well known experts in the field of PD measurement who have published hundreds of technical papers on the subject and performed thousands of PD measurements on all the different types of HV equipment covered in the book The authors have also had relationships with PD detector manufacturers giving them key insights into test instruments and practical measurements Sample topics covered in the work include Physics of PD discharge phenomena contact sparking and vibration sparking and an introduction to PD measurement electrical optical acoustic and chemical Electrical PD detection types of sensors RF PD detection antenna TEV and PD instrumentation and display Off line and on line PD measurements general principles of PD interpretation and laboratory PD testing of lumped test objects PD in different types of HV equipment power cables power transformers air insulated metal clad switchgear rotating machines gas insulated switchgear and more For HV equipment OEMs users of HV equipment or employees of companies that provide PD testing services to clients Practical Partial Discharge Measurement on Electrical Equipment is an essential reference to help understand general concepts about the topic and receive expert guidance during specific practical applications

Microwave Electronics L. F. Chen,C. K. Ong,C. P. Neo,V. V. Varadan,Vijay K. Varadan,2004-11-19 The development of high speed high frequency circuits and systems requires an understanding of the properties of materials functioning at the microwave level This comprehensive reference sets out to address this requirement by providing guidance on the development of suitable measurement methodologies tailored for a variety of materials and application systems Bringing together coverage of a broad range of techniques in one publication for the first time this book Provides a comprehensive

introduction to microwave theory and microwave measurement techniques Examines every aspect of microwave material properties circuit design and applications Presents materials property characterisation methods along with a discussion of the underlying theory Outlines the importance of microwave absorbers in the reduction in noise levels in microwave circuits and their importance within defence industry applications Relates each measurement technique to its application across the fields of microwave engineering high speed electronics remote sensing and the physical sciences This book will appeal to practising engineers and technicians working in the areas of RF microwaves communications solid state devices and radar Senior students researchers in microwave engineering and microelectronics and material scientists will also find this book a very useful reference

Smart Sensors for Industrial Applications Krzysztof Iniewski, 2017-12-19 Sensor technologies are a rapidly growing area of interest in science and product design embracing developments in electronics photonics mechanics chemistry and biology Their presence is widespread in everyday life where they are used to sense sound movement and optical or magnetic signals The demand for portable and lightweight sensors is relentless in several industries from consumer electronics to biomedical engineering to the military *Smart Sensors for Industrial Applications* brings together the latest research in smart sensors technology and exposes the reader to myriad applications that this technology has enabled Organized into five parts the book explores Photonics and optoelectronics sensors including developments in optical fibers Brillouin detection and Doppler effect analysis Chapters also look at key applications such as oxygen detection directional discrimination and optical sensing Infrared and thermal sensors such as Bragg gratings thin films and microbolometers Contributors also cover temperature measurements in industrial conditions including sensing inside explosions Magnetic and inductive sensors including magnetometers inductive coupling and ferro fluidics The book also discusses magnetic field and inductive current measurements in various industrial conditions such as on airplanes Sound and ultrasound sensors including underwater acoustic modem vibrational spectroscopy and photoacoustics Piezoresistive wireless and electrical sensors with applications in health monitoring agrofood and other industries Featuring contributions by experts from around the world this book offers a comprehensive review of the groundbreaking technologies and the latest applications and trends in the field of smart sensors

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