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Synthesis and Characterization of Nd:YAG Ceramics for Laser Applications

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Abstract: Materials known as Nd:YAG are crystalline materials of the cubic system made from the neodymium-doped yttrium aluminum garnet, which, among others, have excellent optical properties. Nd:YAG four-level laser devices are frequently used in both the health and industrial sectors. In this study, a simple and inexpensive alternative to manufacturing Nd:YAG materials through solid state reactions following powder processing routes was proposed. For this, an intense mixture of the precursor materials (Al_2O_3 and Y_2O_3) was carried out, followed by the addition of neodymium atoms to improve the optical properties of the resulting material. High-energy mechanical mixing of the precursor powders resulted in submicron particles with good size distributions of the powders. The advance of YAG formation was monitored by intermediate phase formation during heat treatment through interrupted tests at different temperatures and analysis by X-ray diffraction. From this analysis, it was found that reaction for the formation of the desired YAG is completed at 1500 °C. Fourier transform infrared spectroscopy analyses determined the presence of functional groups corresponding to the YAG. Finally, the study employing optical emission spectroscopy showed wavelengths in agreement with those of the electronic structure of the elements of the synthesized Nd:YAG.

Keywords: Nd:YAG; laser; optical characterization



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1. Introduction

Materials known as neodymium-doped yttrium aluminum garnet (Nd:YAG) are crystalline materials of the cubic system made from neodymium-doped yttrium aluminum garnet. These materials have excellent physical, chemical, thermal, mechanical, and optical properties [1–7]. One of the applications of this type of material is its widespread use in white-light emitter manufacturing. However, the development of lasers has always been conditioned by the availability of suitable materials for their use. In 1995, Ikesue et al. demonstrated that transparent Nd:YAG ceramics could be produced using ceramic fabrication techniques such as dry pressing and sintering [2]. Therefore, sintering of active media by ceramic methods has become an alternative for solid-state laser active media manufacturing. The addition of dopants during the processing of ceramic materials favors the generation of concentration gradients that successfully modify the characteristics of the materials [3].

There are different synthesis routes for Nd:YAG, including the solid-state reaction, the solvothermal synthesis and a lot of wet chemical methods. As an example, the Nd:YAG has been synthesized by means of Colloidal suspension of primary oxides (i.e., Y_2O_3 ,

Characterization Of Ceramics

**Terry V. Roszhart, Jack R. Bohn, TRW
SYSTEMS GROUP REDONDO BEACH
CALIF.**

Characterization Of Ceramics:

Characterization of Ceramics Ronald E. Loehman, Ronald Loehman, 2010 Ceramics are in a general definition materials that consist of man made inorganic non metallic solid material either existing in a crystalline state or non crystalline state i.e glasses Materials characterization techniques are used to ensure the structural and surface integrity of ceramics for their use in a wide variety of applications from thermal resistance to advanced electronic and optical technologies like fiber optics to structural uses This book presents those techniques along with views on future trends in ceramics processing and advanced characterization technologies particularly appropriate to ceramics materials Readers will find more on Ceramic Materials preparation routes including powder preparation by solution techniques and gas phase techniques Formation techniques for ceramic films and coatings thick films and bulk ceramics A review of ceramic microstructure reactions phase behavior mechanical properties and electronic and magnetic ceramics *Characterization of Ceramics* Larry L. Hench, Robert

William Gould, 1971 **Chemical Characterization of Ceramic Pastes in Archaeology** Hector Neff, 1992 Advanced Ceramics for Dentistry Saso Sturm, Boštjan Jančar, 2013-09-05 Microstructure characterization of advanced ceramics involves qualitative and quantitative analysis of surface topography porosity crystal defects and interfaces The structure of the surface controls interaction of ceramics with its surroundings such as adhesion gas adsorption and electron exchange which play an important role in determining overall properties of a material Pores in ceramic materials originate from incomplete densification during the sintering process Their presence interferes with functional properties such as mechanical strength optical transparency electrical conductivity and dielectric response Crystal defects mostly form either as a result of imperfections during the crystal growth process or as a consequence of structural phase transitions They generally affect most functional properties of materials So called extended defects are interfaces that are boundaries between two solids The most widespread tools for characterization of ceramic microstructures are microscopic techniques involving optical microscopy different types of electron microscopy and various scanning probe methods This chapter gives a brief introduction of the features of ceramic microstructure and the corresponding techniques for characterizing them

Characterization of Ceramic Materials Hamuyuni, 2019-11-20 **Advances in Ceramics** Costas Sikalidis, 2011-08-09 The current book contains twenty two chapters and is divided into three sections Section I consists of nine chapters which discuss synthesis through innovative as well as modified conventional techniques of certain advanced ceramics e.g target materials high strength porous ceramics optical and thermo luminescent ceramics ceramic powders and fibers and their characterization using a combination of well known and advanced techniques Section II is also composed of nine chapters which are dealing with the aqueous processing of nitride ceramics the shape and size optimization of ceramic components through design methodologies and manufacturing technologies the sinterability and properties of ZnNb oxide ceramics the grinding optimization the redox behaviour of ceria based and related materials the alloy reinforcement by ceramic particles

addition the sintering study through dihedral surface angle using AFM and the surface modification and properties induced by a laser beam in pressings of ceramic powders Section III includes four chapters which are dealing with the deposition of ceramic powders for oxide fuel cells preparation the perovskite type ceramics for solid fuel cells the ceramics for laser applications and fabrication and the characterization and modeling of protonic ceramics *Ceramic Materials* Dolores Eliche Quesada, Luis Perez Villarejo, Pedro Sánchez Soto, 2019-03-20 Scientific and technological development has led to the formulation of tailor made materials which have given rise to materials with new structural and industrial applications This book aims to analyze the synthesis characterization and applications of ceramic materials This includes an introduction to traditional and advanced ceramics the use of traditional ceramic materials as ideal candidates for absorbing wastes and the synthesis and characterization of advanced ceramics as nanoceramics yttria ceramics and electronic ceramics

Characterization Techniques of Glasses and Ceramics Jesus Ma. Rincon, Maximina Romero, 2013-06-29 This book covers a wide range of lectures given at the Short Summer Course celebrated at La Laguna University about the new trends in the modern characterization methods chemical microscopies thermal X ray resonance and nuclear methods for ceramics glasses and related materials This book also looks also at the zeolite thermal characterization methods as well as the new approaches in new microscopies for the investigation of surfaces in materials Nowadays is generally accepted in the scientific community that characterization methods must be used in research from a complementary point of view The conscious application of several characterization techniques in the same material is very useful not only for obtaining a best knowledge of the material characteristics but also to answer scientific and technical questions about the processing and properties of final products Whereas the introducing chapter in chemical analysis of rare earths the several methods here described looked as complementary methods which can be used in the investigation of ceramics and glasses The major part of the book is devoted to fundamentals and applications of the techniques with a direct style which makes the book easy to read being particularly useful for anyone beginning in research and applications of ceramics glasses and glass ceramics Each chapter include clear figures and additional references for those interested in obtaining a depth knowledge in different techniques High Strain Rate Characterization of Ceramics in Shear Mahesh K. Chengalva, Amos Gilat, 1990

Holographic Characterization of Ceramics. Part III. Measurement of Surface Roughness Terry V. Roszhart, Jack R. Bohn, TRW SYSTEMS GROUP REDONDO BEACH CALIF., 1973 The measurement of rough material surfaces using coherent laser light is investigated A stochastic analysis relating the statistical parameters of random surfaces to the statistical parameters of a coherent diffraction pattern scattered by the surface is presented The relationship of the standard deviation σ_z and the autocorrelation distance T_z to the average bi directional light intensity is shown as is the probability density function of the individual coherent intensities The experimental verification of theory is then demonstrated and the optical characterization of surfaces with known properties is performed The application of these techniques to the characterization

of ceramic surfaces and processes is discussed Author **On-Line Quantitative Nondestructive Evaluation and Characterization of Tough Ceramics at Operating Temperatures (DURIP)**. Christian P. Burger, TEXAS A AND M RESEARCH FOUNDATION COLLEGE STATION., 1990 A grant of 70 000 from AFOSR was used to buy a 600W CO₂ laser This was combined with items bought with supplemental funds from other sources to assemble a facility for characterization of ceramic materials at extremely high temperatures up to 2000C is anticipated in air The system splits the laser beam into two equal components each of which is coupled into its own computer controlled galvanometric scanner that scans the beam rapidly over a central portion of the front or back surface of a flat specimen The scan rate and scan density is controlled to yield a test volume in the mid section of the specimen that is at uniform temperature and free of thermal stresses Related research is developing non contact methods for stain measurements and damage detection within the central volume of material that is at the test temperature Characterization of material properties and behavior in a wide range of severe environments will be possible with this system Keywords Tough ceramics Non destructive evaluation High temperature JES

Sintering and Mechanical Characterization of Ceramics in the Zr-C-O System P Barnier, F Thevenot, Institute of Metals, London (GB). British Industrial and Scientific International Translation Service, 1989 **Characterization of Ceramics and Intermetallics Fabricated by Self-propagating High-temperature Synthesis**, 1989 **Advanced Characterization Techniques for Ceramics** Wayne S. Young, G. L. McVay, Gordon E. Pike, 1989 Synthesis and Thermoluminescent Characterization of Ceramics Materials Teodoro Rivera, 2011 *Holographic Characterization for Ceramics* Terry V. Roszhart, Durk J. Pearson, Jack R. Bohn, TRW SYSTEMS GROUP REDONDO BEACH CALIF., 1971 A study of the application of a group of pulsed ruby holographic techniques to a variety of ceramic materials testing problems was conducted A pulsed ruby laser system capable of holographically imaging dynamic large volume events is described The system was coupled with holographic interferometry microscopy and correlation for application to residual stress measurements property evaluation crack propagation nondestructive testing long working distance microscopy and large strain measurement It is concluded that pulsed ruby holographic instrumentation will become a powerful rugged and sensitive tool for materials research and testing Author **Characterization and Modeling to Control Sintered Ceramic Microstructures and Properties** C. DiAntonio, 2012-04-17 These proceedings are designed to provide a forum that integrates research in characterization and modeling to advance the science of ceramic composite sintering Densification shape deformation and microstructure evolution during sintering is addressed **Holographic Characterization of Ceramics. Part IV. (Measurement of Surface Roughness on Si₃N₄ Bearing Surfaces)**. T. V. Roszhart, TRW SYSTEMS GROUP REDONDO BEACH CALIF., 1973 A method for measuring the surface roughness of ceramic bearings was developed using coherent light techniques The method is noncontacting and nondestructive and is applicable to cylindrical and spherical surface geometries Surface roughnesses varying from 193 microinches to 9 46 microinches A A were measured in

the longitudinal and circumferential directions on typical Si₃N₄ bearing specimens This technique referred to as Coherent Surface Analysis determines surface roughness by analyzing the scattering of a laser beam from random surfaces Since the laser beam can be scanned over the entire surface it is possible to measure point to point variations in roughness This feature was used to measure the change in surface roughness caused by rolling contact fatigue Author **Advances in Ceramics** Costas Sikalidis, 2011-08-09 The current book contains twenty two chapters and is divided into three sections Section I consists of nine chapters which discuss synthesis through innovative as well as modified conventional techniques of certain advanced ceramics e g target materials high strength porous ceramics optical and thermo luminescent ceramics ceramic powders and fibers and their characterization using a combination of well known and advanced techniques Section II is also composed of nine chapters which are dealing with the aqueous processing of nitride ceramics the shape and size optimization of ceramic components through design methodologies and manufacturing technologies the sinterability and properties of ZnNb oxide ceramics the grinding optimization the redox behaviour of ceria based and related materials the alloy reinforcement by ceramic particles addition the sintering study through dihedral surface angle using AFM and the surface modification and properties induced by a laser beam in pressings of ceramic powders Section III includes four chapters which are dealing with the deposition of ceramic powders for oxide fuel cells preparation the perovskite type ceramics for solid fuel cells the ceramics for laser applications and fabrication and the characterization and modeling of protonic ceramics **A New Technique for Fracture Characterization of Ceramics at Room and at High Temperature** JY. Pastor, J. Planas, M. Elices, 1995 A new technique for performing stable tests in ceramic materials is analyzed in depth The new feature consists in using an analog output of a laser metrology apparatus that measured the crack mouth opening displacement CMOD as the feedback signal to control a servohydraulic testing machine In this study we go deeply into the analysis of the experimental parameters that control the performance of this technique Finally the temperature dependence is shown for the fracture parameters obtained from stable tests of single edge pre cracked beam specimens SEPB of 3 mol% Y TZP

Unveiling the Energy of Verbal Artistry: An Psychological Sojourn through **Characterization Of Ceramics**

In some sort of inundated with displays and the cacophony of instantaneous conversation, the profound power and emotional resonance of verbal art usually disappear in to obscurity, eclipsed by the regular barrage of sound and distractions. Yet, situated within the musical pages of **Characterization Of Ceramics**, a charming work of fictional brilliance that impulses with organic emotions, lies an wonderful journey waiting to be embarked upon. Composed by a virtuoso wordsmith, this mesmerizing opus courses visitors on a mental odyssey, softly revealing the latent possible and profound impact stuck within the complex web of language. Within the heart-wrenching expanse of the evocative examination, we will embark upon an introspective exploration of the book is central themes, dissect their fascinating publishing style, and immerse ourselves in the indelible effect it leaves upon the depths of readers souls.

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