2 Materials Characterization

Professor : Dr. Yoshihisa Watanabe

Lecturer : Dr. Keisuke Ishii

Keywords: thin films, CVD, PVD, surface modification, piezoelectric ceramics, nonlinear piezoelectricity, orientation control

Materials Characterization conducts research and education about the material measurement and analysis to evaluate the mechanical, electric, magnetic, optical and thermal characteristics of materials.

Yoshihisa Watanabe

tel. +81-46-841-3810 (ext. 2204)

fax +81-46-844-5910

email: ywat@nda.ac.jp

Professor; *Dr. Science. ; Department of Physics, Tohoku University, 1982*

Ceramic Thin films, Chemical Vapor Deposition, Ion Beam Assisted Deposition, Nano-meter scaled observations, Atomic Force Microscopy, Nano Indentation

I. Synthesis and characterization of ceramic thin films

Ceramic thin films are synthesized by chemical and/or physical vapor deposition method, and their structure, properties and surface morphology are examined. Detailed topics are:

(1) Synthesis of diamond thin films from a gas mixture of methane and hydrogen by hot-filament CVD and studying the nucleation and growth process of diamond particles. By using carbon fibers or carbon thick films, enhancement of diamond nucleation on unscratched substrates is succeeded.
(2) Synthesis of aluminum nitride thin films by ion-beam assisted deposition method, and studying the influence of deposition conditions, such as ion-beam energy, substrate temperature and deposition rate, on the film structure, optical properties and surface morphology. In addition, durability of AlN films is studied by exposing films to atmosphere. Furthermore, compositional grading films of AlN and Al are synthesized by controlling an amount of aluminum vapor.
(3) Synthesis of nitrogen-containing carbon (C-N) films by hot filament CVD using a hot carbon filament and pure nitrogen gas as source materials. Chemical states of nitrogen in the films are examined by XPS and mechanical properties are now studying by a nano-indentation method.

II. Nanometer-scale observations of material surfaces

Surfaces and fracture surfaces of materials are observed with atomic force microscopy (AFM) and scanning tunneling microscopy (STM), and surface dynamic processes are studied on the nanometer scale. Detailed topics are:

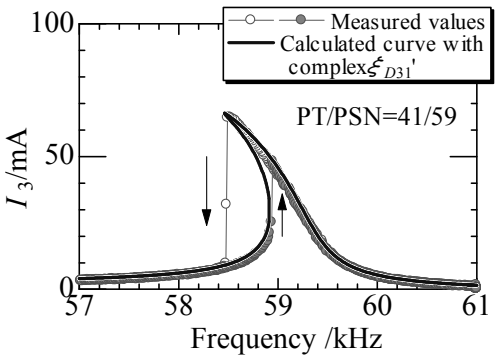
(1) Observations of surfaces of aluminum nitride thin films corroded by acid and basic solutions and studying the initial stage of corrosion processes.
(2) Observations of surfaces of aluminum nitride thin films prepared with different deposition periods and studying the film growth processes.
(3) Observations of fracture surfaces of silicate glasses exposed to air and studying the change in the surface morphology during air exposure.

Keisuke Ishii

Key words: Piezoelectric ceramics, Nonlinear piezoelectricity, Grain orientation, Lead-free

1. Evaluation of nonlinear piezoelectric phenomena in piezoelectric ceramics

Piezoelectric ceramics are widely used as indispensable elements in electrical devices. The nonlinear piezoelectric phenomena, which frequently appear in the ceramics driven under high power conditions, induce serious problems in the practical use. We aim to elucidate the detailed generation mechanism of the nonlinearity by the quantitative analysis and to search the piezoelectric materials which have a smaller nonlinear piezoelectricity. The current jump phenomenon is one of the typical nonlinear phenomena, and that measurement curve is successfully reproduced by the exact simulation curve obtained from our quantitative analysis (see figure).



2. Study of new technique for grain orientation in piezoelectric ceramics

Since the piezoelectric ceramics with more excellent properties can be fabricated by using the grain orientation technique, the development of the effective techniques is one of the essential factors for the study of advanced piezoelectric ceramics. We originally developed the rolling-extended method, in which the clay-like green sheets are extended by a roller (see figure). The lead-free ferroelectric samples with bismuth-layer structure and tungsten-bronze structure fabricated by this method are characterized.