- Sept. 1983～Sept. 1984 Guest Scientist, Radiation Effects and Microstructural Analysis Group, Metal and Ceramics, Oak Ridge National Lab.
  Grain Boundary Segregation after Neutron Irradiation; Investigating correlation between mechanical properties and radiation damage under neutron irradiation.

V. Research Interest:

Dr. Kishimoto majors quantum beam technology utilizing the unique characteristics, which is the key to create breakthroughs in materials science and technology. Among them, synchrotron radiation, neutrons and ion beams are promising both for nanofabrication and characterization. The quantum beam technology is effective not only for solid-state nanomaterials but also polymers and biomaterials. In particular, he has focused on nanoparticles embedded in dielectric insulators and polymers using heavy-ion implantation, and obtained ultra-fast nonlinear optical properties. The near-field effects are effective for not only optical switching but also various bioapplications.

Their unique method of negative ions is free of surface-charging and good for insulating materials/polymers and, consequently, effective in realizing precise nanopatterning. The dielectric substrates for ion implantation are SiO2, MgAl2O4, LiNbO3, MgO, TiO2, SrTiO3 and various polymers, PE, PMMA, PS and PC. The ion-polymer interactions provide new functionalities, such as hydrophilic/hydrophobic control and cell adhesion. He also succeeded in nano-patterning of ion implantation, either by stencil-masked implantation or by ion-laser coirradiation methods. The controlled nanofabrication of nanoparticle-dispersed materials may develop nonlinear optical devices such as optical switching and plasmonic devices.

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Nanomaterials Research Using Quantum Beam Technology

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Quantum beam technology has been expected to develop breakthroughs for nanotechnology during the third basic plan of science and technology (2006～2010). Recently, Green- or Life Innovations has taken over the national interests in the fourth basic science and technology plan (2011～2015). The NIMS (National Institute for Materials Science) has been conducting the corresponding mid-term research plans, as well as other national projects, such as nano-Green project (Global Research for Environment and Energy based on Nanomaterials science). In this lecture, the research trends in Japan and NIMS are firstly reviewed, and the typical achievements are highlighted over key nanotechnology fields. As one of the key nanotechnologies, the quantum beam research in NIMS focused on synchrotron radiation, neutron beams and ion/atom beams, having complementary attributes. The facilities used are SPring-8, nuclear reactor JRR-3, pulsed neutron source J-PARC and ion-laser-combined beams as well as excited atomic beams. Materials studied are typically fuel cell materials, superconducting/magnetic/multi-ferroic materials, quasicrystals, thermoelectric materials, precipitation-hardened steels, nanoparticle-dispersed materials. Here, we introduce a few topics of neutron scattering and ion beam nanofabrication. For neutron powder diffraction, the NIMS has developed multi-purpose pattern fitting software, post RIETAN2000. An ionic conductor, doped Pr2NiO4, which is a candidate for fuel-cell material, was analyzed by neutron powder diffraction with the software developed. The nuclear-density distribution derived revealed the two-dimensional network of the diffusion paths of oxygen ions at high temperatures. Using the high sensitivity of neutron beams for light elements, hydrogen states in a precipitation-strengthened steel were successfully evaluated. The small-angle neutron scattering (SANS) demonstrated the sensitive detection of hydrogen atoms trapped at the interfaces of nano-sized NbC. This result provides evidence for hydrogen embrittlement due to trapped hydrogen at precipitates. The ion beam technology can give novel functionality on a nano-scale and is targeting applications in plasmonics, ultra-fast optical communications, high-density recording and bio-patterning. The technologies developed are an ion-and-laser combined irradiation method for spatial control of nanoparticles, and a nano-masked ion irradiation method for patterning. Furthermore, we succeeded in implanting a wide-area nanopattern using nano-masks of anodic porous alumina. The patterning of ion implantation will be further applied for controlling protein adhesivity of biopolymers. It has thus been demonstrated that the quantum beam-based nanotechnology will lead the innovations both for nano-characterization and nano-fabrication.