5 ERATO Non-Equilibrium Dynamics Project

5-1 Outline

Introduction

The ERATO Non-Equilibrium Dynamics Project of the Japan Science and Technology Agency (JST) has been actively working for the past three years at KEK. The project is financially supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the project director is Prof. Shin-ya Koshihara, Professor at the Department of Chemistry and Materials Science of the Tokyo Institute of Technology.

The goal of the project is to reveal the physics of ultrafast non-equilibrium dynamics in condensed matter using pulsed X-rays. The project is devoted to (1) construction and development of beamline NW14A fully dedicated to X-ray diffraction, scattering and absorption measurements, (2) structure analysis of non-equilibrium states based on sub-ns-resolved X-ray diffraction using the single-bunch mode of the PF-AR, (3) synthesis of organic and non-organic crystals that show dynamics strongly correlated between photons, electrons, and phonons triggered by fs laser pulses, (4) characterization of photo-induced phase transitions with conventional optical measurements, and (5) feasibility studies to realize dynamic imaging with fs resolution using newly-developed fs X-ray sources.

In addition to the research group directly under the project, we are also collaborating with other groups. There are branches at the Tokyo Institute of Technology for the preparation of inorganic crystal materials and at Kyoto University for the preparation of organic ones. We are also collaborating with a group at Osaka City University for protein crystals with photosynthetic reaction centers. Another branch at the Tokyo Institute of Technology is working on crystal characterization using optical methods. The administrative section of the project is located at KEK. Collaborations with the University of Rennes 1 in France and the Laurence Berkeley National Laboratory in the USA also began in 2004.

Members

Studying various photo-induced phenomena requires researchers from various fields, such as ultrafast laser science, solid state physics, crystallography, sample preparation and synchrotron-radiation instrumentation. At the moment, the project consists of 11 members - the group leader, three ERATO researchers, a post-doctoral researcher, three PhD students, and three administrative staff (Fig. 1).

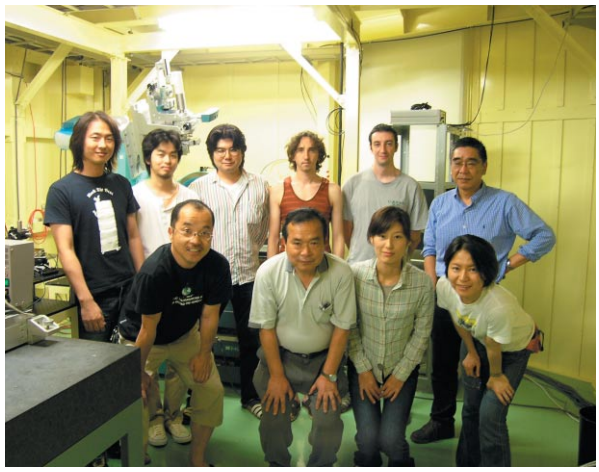

Figure 1
Members of the project.

5-2 Research Subjects

Photo-induced phase transitions (PIPT)

The main subject of the project is the investigation of photo-induced structural transitions in solids using the optical-pump and X-ray probe technique. Much effort has been made on the study of photo-induced phase transitions of organic and inorganic materials at the newly constructed beamline AR-NW14A.

Since most of the investigated compounds are studied under the irradiation of a relatively low repetition-rate laser (1 Hz-1 KHz), the pulsed X-ray signal must be isolated or gated during the pump-probe X-ray diffraction experiment. Therefore a relatively low repetition-rate operation of the storage ring is essential. As the PF-AR is a unique facility where the normal operation mode is single bunch. It is possible to perform time-resolved X-ray diffraction experiments during all the operation time of the stroge ring, and this was the main reason why our project is based at KEK.

Other applications using pulsed X-rays

In addition to the PIPT studies, we are developing various application techniques using pulsed X-rays. These include time-resolved (TR-) XAFS, TR-protein crystallography and TR-solution scattering. These experimental setups were shown to be feasible at NW14A, and preliminary experiments using TR-XAFS and TR-protein crystallography have begun.

5-3 Beamline Development

NW14A beamline

The construction of the new beamline NW14A for time-resolved X-ray diffraction, scattering and absorption experiments was completed in the summer of 2005 (Fig. 2). The beamline was commissioned during Octo-

ber-December 2005, and user operation successfully began in January 2006. The current status of NW14A is described elsewhere in this volume (See pp. 83).

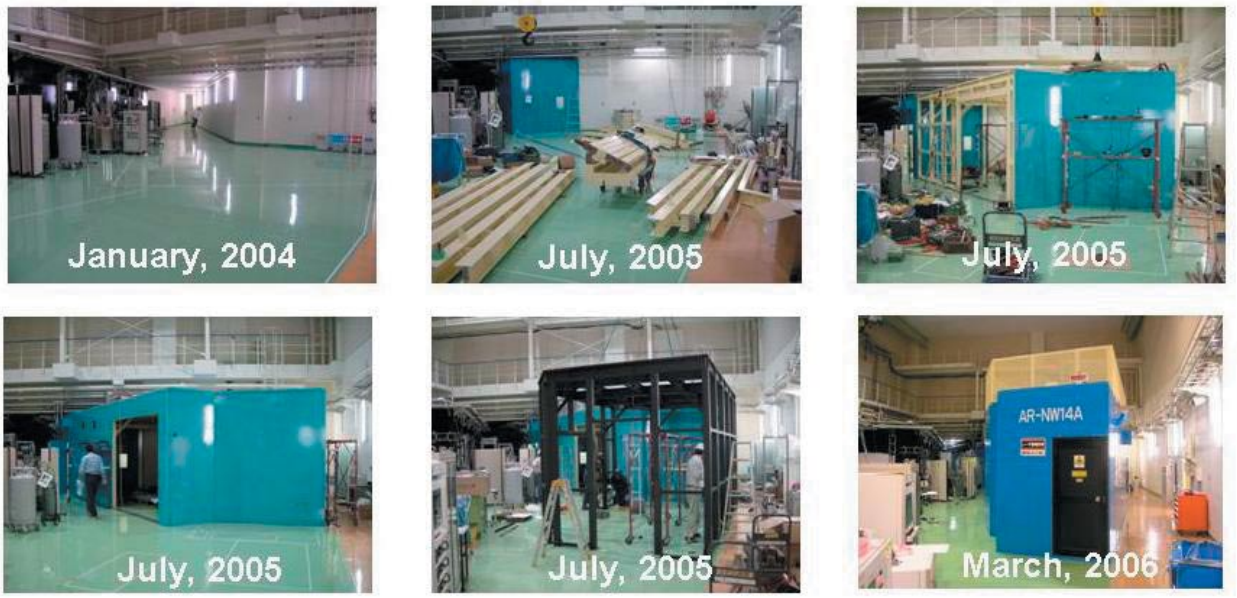

Figure 2
Construction of beamline NW14A.