SPring-8

Real-Time Observation of Nanosecond Crystal Growth Process in DVD Materials

The first experiment of nanosecond scale time-resolved pump and probe X-ray diffraction in SPring-8 has been conducted for the phase change phenomena of DVD-RAM (Digital Versatile Disc - Random Access Memory) materials. The work was carried out with the "X-ray pinpoint structural measurement" system developed at High Flux Beamline BL40XU.

The development of the X-ray pinpoint structural measurement system is a pilot project organized by Japan Science and Technology Agency (JST) as the Core Research for Evolutional Science and Technology (CREST). The project was started in 2004 and will be completed by 2009. The aim of the project is to realize the picosecond time resolved X-ray diffraction experiment using submicron scale beam. This is why the project is termed "pinpoint". Specialists in accelerator science, laser physics, X-ray optics, diffraction physics, crystallography and chemistry have joined this project from several institutes: JASRI/SPring-8, RIKEN SPring-8 Center, Matsushita Electric Industrial, Tsukuba University and University of Hyogo. The aimed specifications of the X-ray pinpoint structural measurement are ~100 nm spatial resolution and ~40 ps time resolution [1]. To ensure the precision of the time resolution, we devised a new precise timing control system, which allows us to hold the timing accuracy within 5 picosecond under any condition [2].

Figure 1 shows the X-ray pinpoint structural measurement in the case of the DVD-RAM experiment mode. The amorphous-crystal phase change, utilized for optical memory in DVD-RAM, is still an unsolved mystery and an attractive phenomenon from the viewpoint of structural materials science. In order to find out much faster phase-change materials, an understanding of the structural mechanism to cause the fast phase change of DVD-RAM materials has been strongly required.

The time-resolved diffraction data have been obtained for crystallization from the as-deposited amorphous phase of DVD materials, $Ge_2Sb_2Te_5$ (GST) and $Ag_{3.5}In_{3.8}Sb_{75.0}Te_{17.7}$ (AIST). The optical reflectivity measurement was also carried out simultaneously to explore the correlation between the structure and optical property changes (see Fig.2). The result revealed, for the first time, a significant difference between the crystallization processes of GST and AIST [3]. Consequently, the X-ray pinpoint structural measurement system is now close to the completion in SPring-8. The system which is the integration of the time-resolved experiment and sub-micron beam technique will be applied to photo-induced phenomena, structural change under applied AC electric field, etc.

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[1] S. Kimura et al., AIP conference proceedings **879**, 1238 (2007).
[2] Y. Fukuyama, Y. Tanaka, et al., Rev. Sci. Instrum. **79**, 045107 (2008).
[3] Y. Fukuyama et al., Appl. Phys. Express, **1**, 045001 (2008).

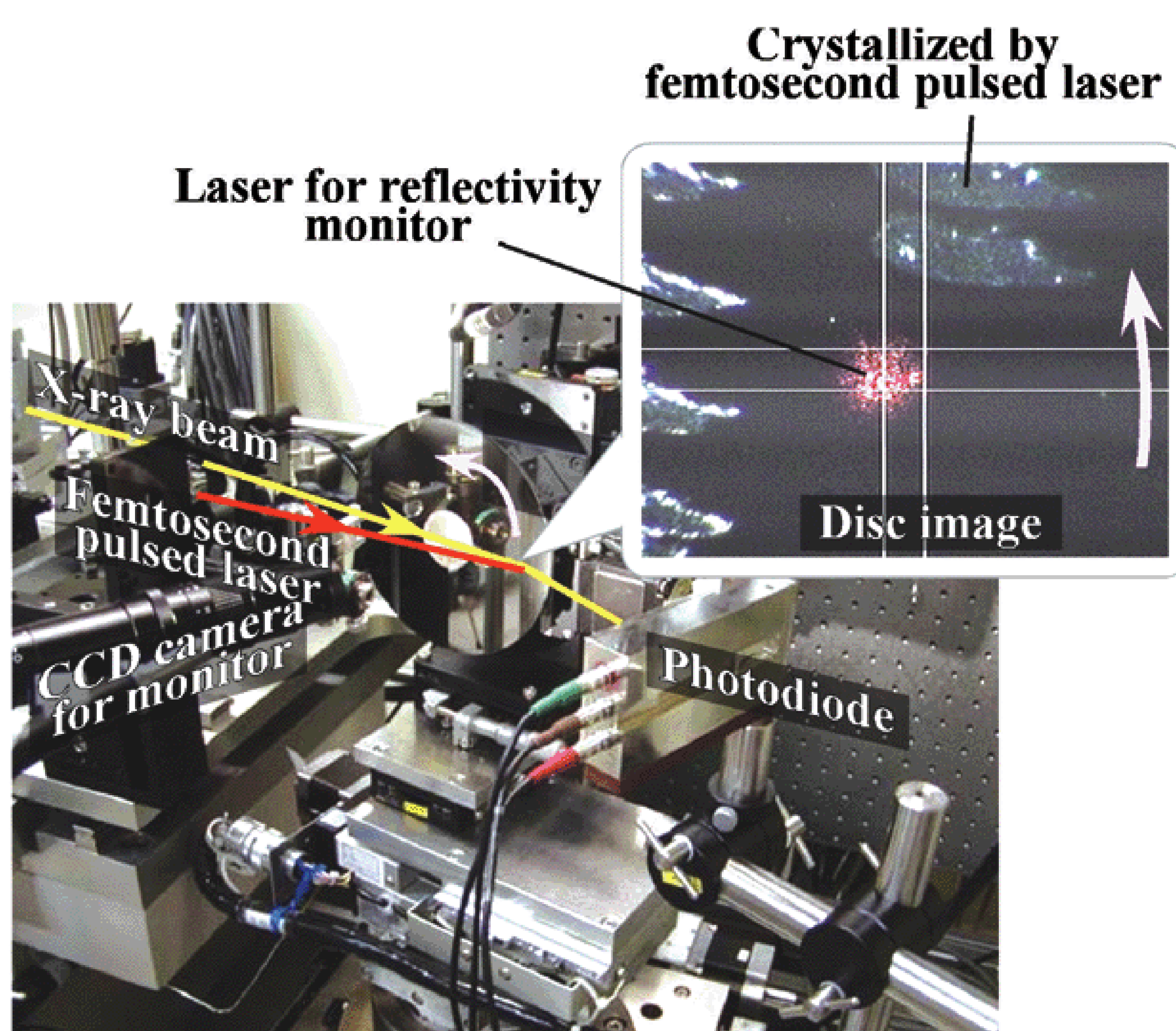
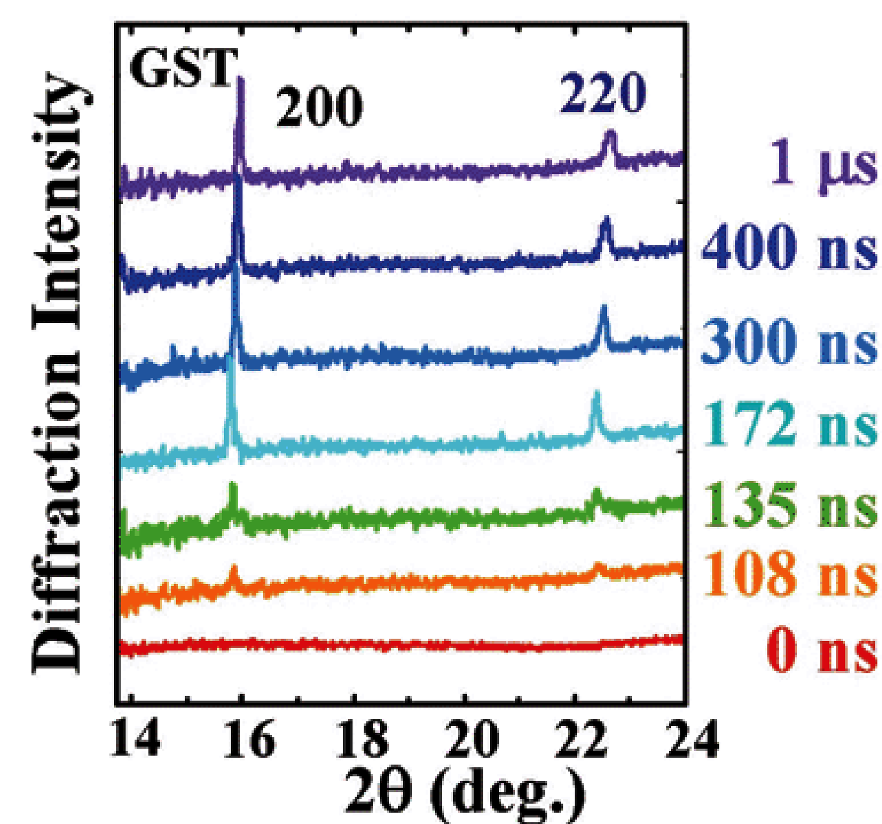


Figure 1.
Photograph of the time-resolved structural measurement system for DVD-RAM materials. A DVD disc is rotated during the measurement to supply the virgin amorphous surface.



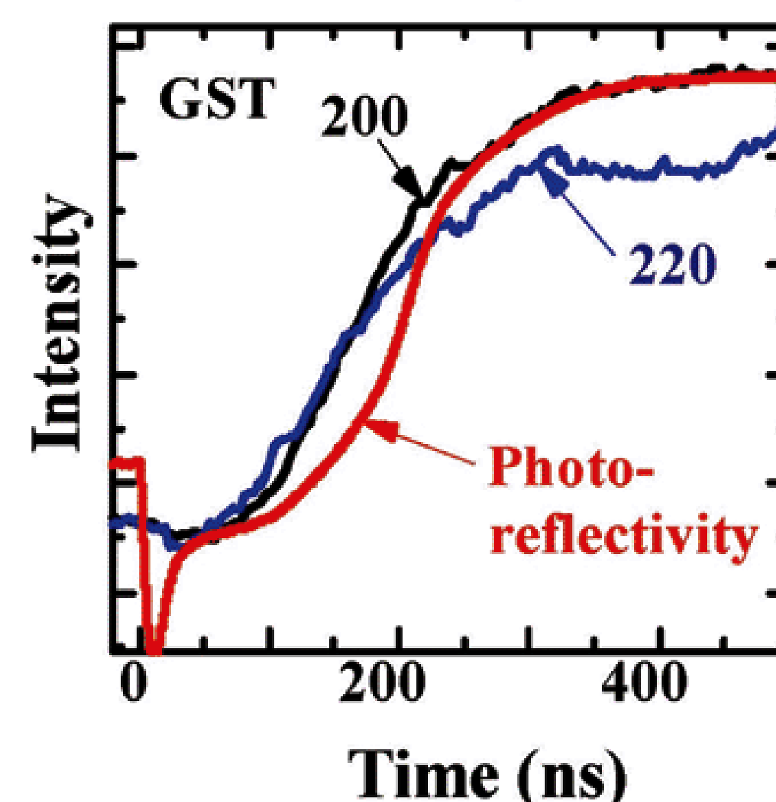
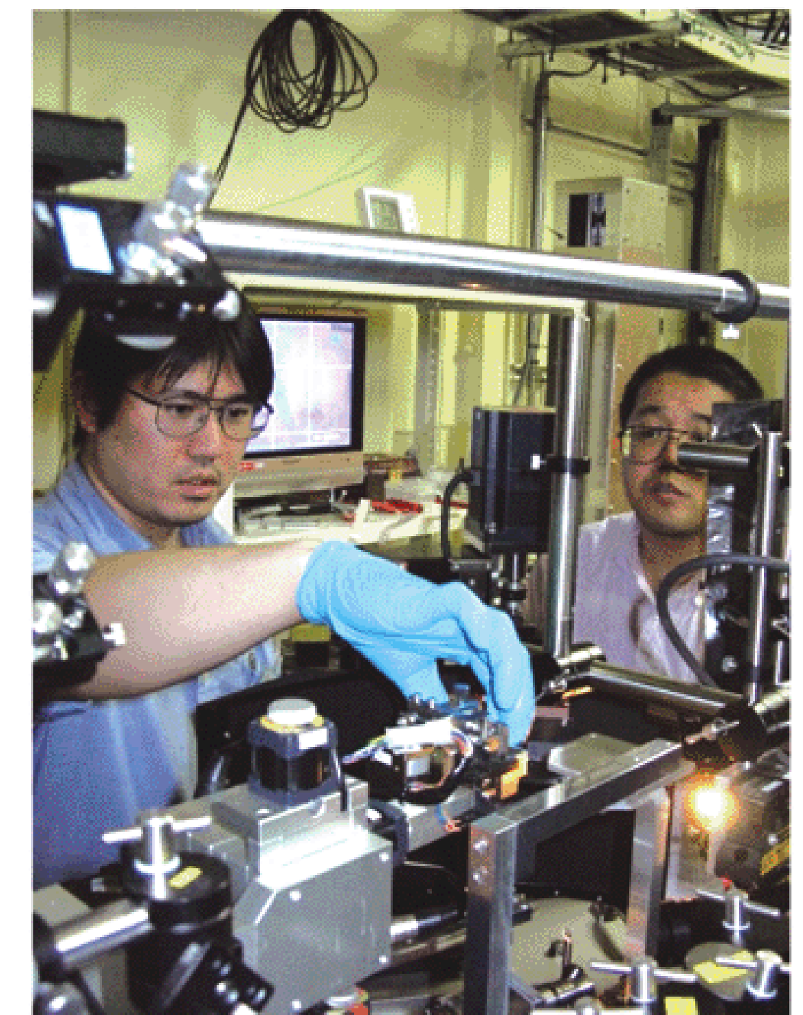


Figure 2.
Time-dependent X-ray diffraction patterns (upper), and diffraction peak intensity and photoreflectivity (lower) for GST.



Snapshot at the pinpoint structural measurement system.