ESRF	**Experiment title:** Fast Structural Transitions in Single Bits of Phase-Change Storage Media by Nanofocusing-XRD	**Experiment number:** ME-889
Beamline: ID13	**Date of experiment:** from: Jan. 27, 2005 to: Feb. 31, 2005	**Date of report:** March 7, 2006
Shifts: 12	**Local contact(s):** M. Burghammer	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
Christoph Steimer,* Christian Schroer,* Matthias Wuttig, Stephan Ziegler, Henning Dieker,* Manfred Burghammer,* Pit Boye,* Jens Patommel,* Olga Kurapova,* Andreas Schropp*

Report:

The aim of this experiment was to analyze the crystalline structure in single crystalline bits written into an amorphous film (thickness 80nm) of a phase change medium, such as $Ge_2Sb_2Te_5$. Fig. 1(a) shows an SEM image of such a bit. It was to be verified, whether the same crystalline phase is generated by laser heating and fast cooling of a small region (bit) as by generating a crystalline film by slow annealing. To this end, a series of bits (each about 3μm in diameter) were written into a thin film of $Ge_2Sb_2Te_5$ supported by a Si_3N_4-membrane (thickness 200 nm). A crystalline film generated by annealing was used as a reference sample.

This experiment was the first user experiment that was made with the nanoprobe setup at ID13 based on silicon refractive x-ray lenses. The nanobeam was set up during a preparatory experiment (MI-704-3) just before this experiment and had a lateral size of $100 \times 180\text{nm}^2$ at $E = 15.2\text{keV}$ and a flux of about $6 \cdot 10^8\text{ph/s}$ (see exp. rep. MI-704-3 for details). To help finding the bit structures on the substrate and putting them into the beam, a Cu TEM-grid fixed to the substrate served as reference. However, in spite of the grid, it was not easy to locate the bit structures, mainly because it was not known a priori how strong a diffraction signal was expected. Since the nanobeam illuminates just a few nanocrystals (integrally about 10^7 unit cells), only a few of which fulfill the diffraction condition, only a few single reflections are observed in the diffraction patterns. Fig. 2 shows a series of diffraction patterns recorded while scanning through a single bit in steps of 500nm and with 90s exposure time, showing varying individual reflections. The strong diffraction rings near the center stem from the diffraction of higher harmonic radiation (45.6keV) at the collimating system.

Evaluation of the peak positions yields that the bit under investigation is in the

favored cubic and not in the hexagonal crystalline phase that are both known to exist for this system. Table 1 shows the d-spacings for different reflections. In addition, the intensity of the reflections varies systematically as a function of position. Fig. 3 shows the diffraction intensities of (200)-reflections at the points 1 to 6 marked in Fig. 2. The (200)-reflections in the center of the bit (point 3 and 4 in zone III) are much weaker but more common than in a broad ring around the center (zone II). This can be understood considering the structure of such a bit that is shown in the TEM image in Fig. 1(b) [1]. At the very border of the bit, a few very small crystallites form zone I in Fig. 2. This zone could not be detected in the experiment as there are too few crystallites in this zone. Zone II in Fig. 2 is formed by larger crystallites that are observed as relatively strong reflections in the points 1, 2, 5, and 6. The central zone III is composed of small crystallites that were detected in the points 3 and 4. Details of this evaluation can be found in the PhD-thesis of O. Kurapova [2].

Figure 1

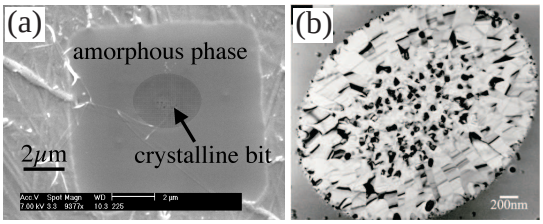

Figure 2

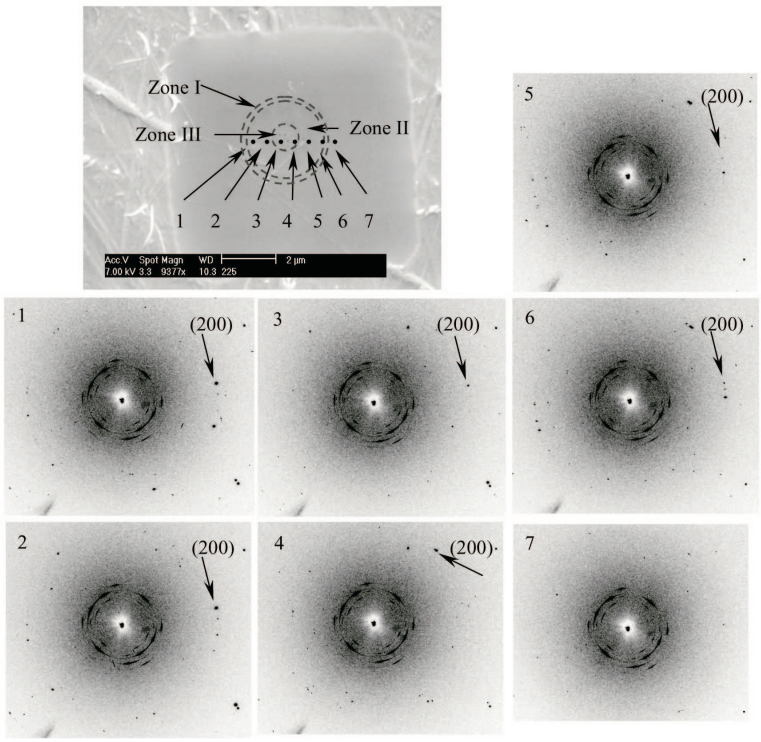

Figure 3

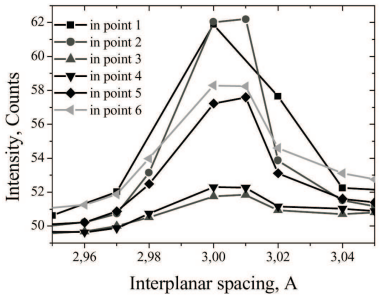

Table 1: d-spacing of crystallites.

hkl	reference Å	bit Å
111	3.47	3.52
200	3.00	3.03
220	2.12	2.14
311	1.81	1.83

In this first experiment, experience was gained about finding these small structures on large substrates and interpreting their diffraction patterns. A more thorough investigation with many more samples is needed in the future to quantify the results obtained above.

References

[1] I. Friedrich, V. Weidenhof, S. Lenk, and M. Wuttig, Thin Solid Films **389**, 239 (2001).

[2] O. Kurapova, Ph.D. thesis, Aachen University (RWTH), 2005.