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A Δd mapping of silicon crystals for the determination of the Avogadro constant

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Introduction

Silicon single crystals are used for the determination of the Avogadro constant, N_A [1]. The N_A value is determined by absolute measurements of lattice constant a, density ρ and mean molar mass M of silicon single crystals from the formula, $N_A = 8(M/\rho)/a^3$.

Natural abundant silicon crystals have been used to determine the N_A so far, and the new International Avogadro Project was recently started in order to determine the N_A with a relative uncertainty of 2×10^{-8} with enriched ^{28}Si crystal. Before producing the ^{28}Si single crystal, several test ingots with natural abundance were grown under the same condition for ^{28}Si at IKZ, Berlin. Evaluation of homogeneity of silicon ingots as well as defects in silicon crystals of the test sample, therefore, is of great importance for the determination of N_A.

Zhang et al. [2, 3] have demonstrated a precision lattice measurement method using synchrotron radiation (SR) at KEK. In this paper, the lattice spacing for the IKZ test ingot was evaluated by this method.

Experiment and discussion

Figure 1 shows principle of the self-referenced lattice comparator. This method uses a pair of semi-simultaneous diffractions in the crystal. A x-ray beam with selected wavelength is used to observe a pair of semi-simultaneous diffractions of (911) and (91 -1) in a silicon crystal. A slight change of the interval of two diffraction peaks was precisely measured to observe the lattice spacing variation in the crystal.

The experiment was performed at the BL3C beamline of Photon Factory at KEK. Since temperature stability and homogeneity of the sample is important for the precise d-spacing mapping experiment, the thermostat was improved to stabilize the temperature of the system.

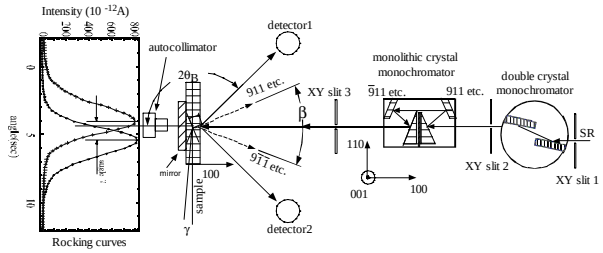

Fig. 1 Schematic drawing of the experimental arrangement.

The experiment was carried out at room temperature and temperature stability of the system is about 1-2 mK. At present, the resolution of $\Delta d/d$ has been achieved to be 2 x10^{-9}.

Figure 2 shows mapping result for the IKZ test sample. A swirl pattern of d-spacing variation is observed. A change of d-spacing is observed and estimated to be less than 4x10^{-8} in $\Delta d/d$ for the IKZ test sample. Several ingots have been evaluated for d-spacing comparison, and similar swirl patterns have been observed. Further study is in progress to clarify the cause of this swirl pattern of Δd mapping.

This result was reported at the IAC (International Avogadro Coordinate) meeting at Broomfield in the United States last June. Now new d-spacing comparison for the isotopically enriched ^{28}Si crystal has been approved by the IAC meeting, and preparation of the measurement is on going.

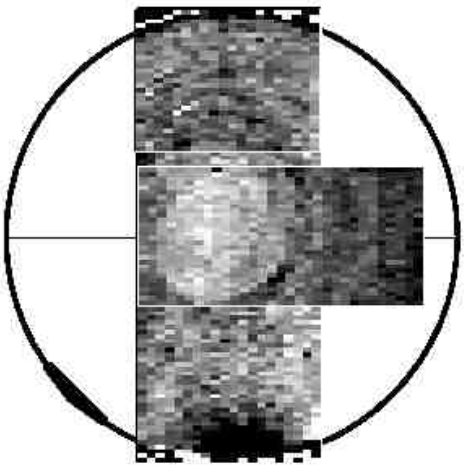

Fig. 2 The d-spacing distribution of IKZ test crystal.

References

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