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Pressure-induced phase transition in III-V compounds at low temperatures

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Introduction

Amorphization from the quenched high pressure phase was studied for many semiconductors [1-3]. Results were analyzed by using a configuration-coordinate model. As the amorphization depends on the height of potential barrier ΔU between the two phases of the before- and after-phase transitions, it is interesting to study the path dependence of the phase transition in III-V compounds with different strength and ionicity of bonds.

Experimental

A diamond anvil cell with a diaphragm was cooled in a cryostat using a He refrigerator. Pressure in the sample was measured by a Ruby fluorescence method with an in-situ pressure measuring system. Pressure can be changed at low temperatures by controlling the He gas pressure in the diaphragm. On decompression, however, a large hysteresis in the gas-pressure vs. generated-pressure relation caused the serious problem in the previous experiments for III-V compounds. The lowest pressure after releasing pressure at low temperature was higher than the transition pressure to an amorphous state. In the present experiment, we used germanium which has relatively higher transition pressure as a sample. In the previous energy-dispersive experiment, only the diffraction intensity in limited diffraction direction region was measured. No sharp diffraction peak may arise not only from transition to an amorphous state but also transition to a single crystal. Therefore, we needs the diffraction intensity along the whole Debye ring. This can be measured with two-dimensional detector of an imaging plate.

Results and discussion

On compression at 300 K, Ge transforms to the high-pressure phase at about 11 GPa. When the pressure was decreased at 70 K, the high-pressure phase was quenched(Fig.1). With increasing temperature at low pressure, the high pressure phase gradually transforms to a mixture of an amorphous phase and metastable crystalline phases with ST-12 and BC-8 structures(Fig.2). These results with the angle-dispersive method are in good agreement with those obtained with an energy-dispersive method.

The lowest pressure at low temperature for experiments of typical III-V compounds should be much lower than that in the present experiments. Some modifications of the DAC for low temperature experiments are needed.

References

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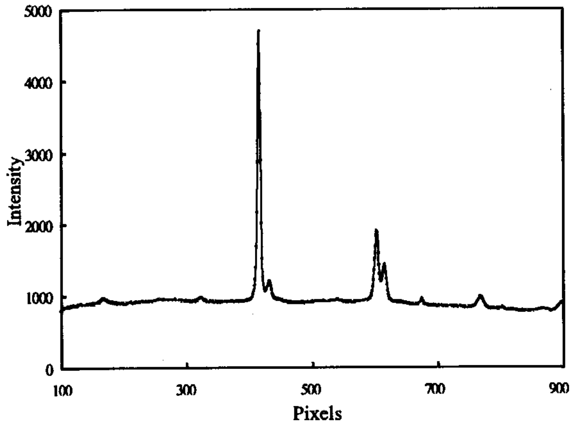

Fig.1 Example of the diffraction intensity as a function of pixel number for germanium at 10.3 GPa and 76 K. Sharp diffraction peaks from the high pressure form.

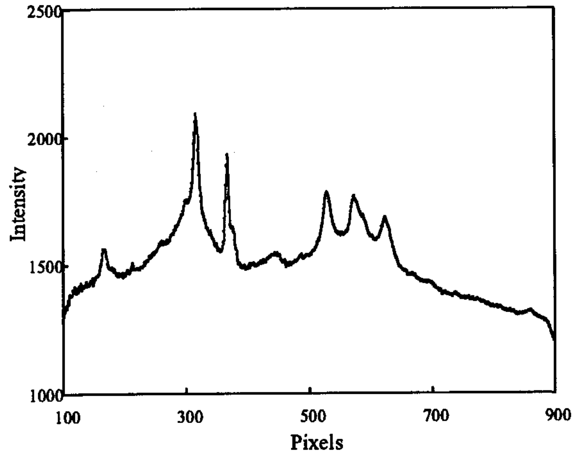

Fig.2 Example of the diffraction intensity as a function of pixel number for germanium at 2.8 GPa and 295 K. Sharp diffraction peaks from the metastable crystalline and broad peaks from an amorphous are observed.

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