【Grant-in-Aid for Scientific Research (S)】
Science and Engineering (Engineering)

Title of Project : Microstructual Control Using High Pressure Allotropy

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【Purpose and Background of the Research】

Metallic elements such as Ti and Zr take a hexagonal close-packed (hcp) structure at ambient pressure and temperature and they transform from the hcp structure (α phase) to a hexagonal structure (ω phase) as the pressure increases [1,2]. This ω phase is hard and brittle in nature, but it may be used as a strengthening phase if it is dispersed finely and homogeneously in the α matrix.

Semiconductors such as Si, Ge and GaAs are also known to exhibit phase transformation when high pressures are applied to the materials. Such transformations introduce a metallic nature into the materials and thus it becomes easier for them to deform plastically. It is then anticipated that the microstructures should be refined through the plastic deformation as other metallic materials.

The aim of this study is to establish microstructural refining process by allotropic phase transformations through introduction of intense strain under high pressures and thus to enhance strength of Ti and Zr without alloying elements and to improve functional properties as photoluminescence in Si, Ge and Ga As.

【Research Methods】

This study uses a process called high-pressure torsion (HPT) as illustrated in Fig.1 (left) where intense strain is introduced under high pressure. Modification is made as shown in Fig.1(right) so that it is possible to measure electrical conductivity during HPT processing. The electrical conductivity is measured as a function of imposed strain and pressure to examine dynamical behavior of allotropic phase transformation. For microanalysis, Rotation DFI [5] as shown in Fig.2 is used.

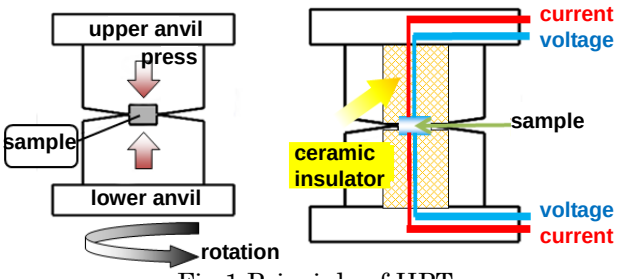

Fig.1 Principle of HPT

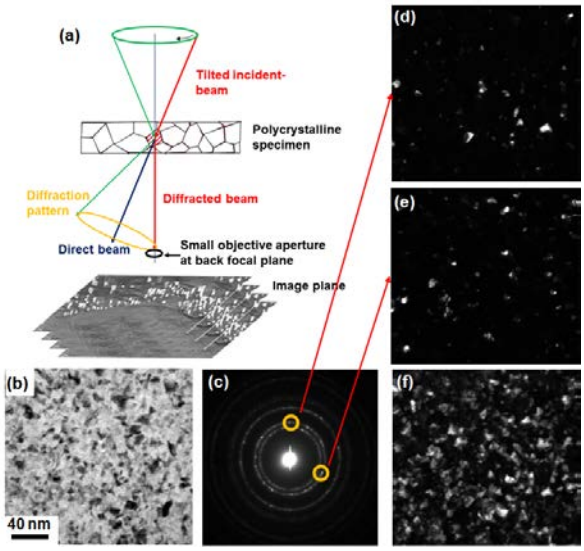

Fig.2 (a) Principle of Rotation DFI [5], (b) bright-field image、(c) selected area diffraction pattern, (d)-(f) dark-field images taken by Rotation DFI.

【Expected Research Achievements and Scientific Significance】

This strengthening process for Ti and Zr is important because alloying elements such as V, Nb and Mo are no longer required. For Si, Ge and GaAs, the grain is refined to the nanosizes in a bulk form and the resultant photoluminescence is important for development of solar battery.

【Publications Relevant to the Project】

[1] G. Gu *et al.*, *Scripta Metall. Mater.*. **31**, 167, (1994).
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[4] B. D. Malone *et al*, *Phys. Rev. B.* **86**, 054101 (2012).
[5]M. Watanabe, *et al.*, *Microscopy and Miroanalysis*, 17, Suppl. 2, 1104 (2011).

【Term of Project】 FY2014-2018

【Budget Allocation】 140,000 Thousand Yen

【Homepage Address and Other Contact Information】

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