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

Broad Section D

Title of Project : Clarification of innovative deformation mechanism in harmonic structure materials and creation of design principle for structure materials for next generation

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Research Project Number : 18H05256 Researcher Number : 10184243
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【Purpose and Background of the Research】

Over many years, ultra-fine grained (UFG) metals have been proved to be attractive structural materials because of superior strength, especially when compared to their coarse-grained (CG) counterparts. However, the downside of homogeneous UFG materials is typically in a low elongation because of the plastic instability in the early stage of deformation. Therefore, fabrication of materials with superior combinations of high strength and high elongation remains a hot issue in material engineering.

The Harmonic Structure (HS) design can be a candidate materials design, which combines high strength with high ductility at the same time. Fig.1 demonstrates a concept of the HS design. As opposed to a "Homogeneous-UFG" material, "HS" material has a unique heterogeneous "Three-dimensionally (3D) Gradient Microstructure" wherein the UFG areas form an interconnected three-dimensional network surrounding CG regions, and CG and UFG areas are periodically arranged in all the directions.

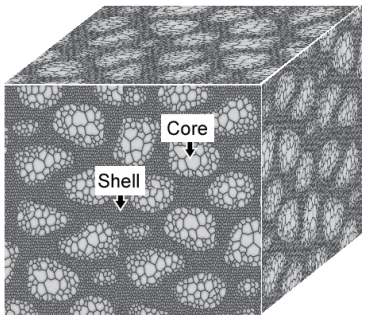

Fig.1 Concept of the HS Design

The HS materials demonstrate various anomalous deformation behaviors, such as "preferential recrystallization", "preferential stress induced transformation", and so on. Therefore, the purpose of the present research project is to reveal these unique deformation behaviors, and to create an innovative structure metallic materials design concept.

【Research Methods】

The first step of the research is to develop efficient process to fabricate the HS materials via several severe plastic deformation powder metallurgy processes. The HS materials are provided to deformation behavior analysis not only by an in-situ SEM deformation analysis facilities but also the Spring-8 synchrotron facility. Simulation techniques such as MD and FEM modellings are also applied to clarify deformation mechanism from the atomic scale.

【Expected Research Achievements and Scientific Significance】

By this research project, we can expect to solve the strength-ductility paradox. Understanding of the micro- and macro-scale deformation mechanisms will be the guide to create innovative structure materials. From the engineering point of view, the HS materials can be fabricated by combination of the classical industrial methods based on the powder metallurgy processes. It is worth to note that this research project will be very useful in the practical applications.

Furthermore, the young researchers as well as students expected to be grown through the international research collaborations in this research project.

【Publications Relevant to the Project】

S.K.Vajpai, M.Ota, Z.Zhang, K.Ameyama, *Three-Dimensionally Gradient Harmonic Structure Design: An Integrated Approach for High Performance Structural Materials*, Materials Research Letters, 4, 191-197, 2016.

J.Li, J.Liu, G.Dirras, K.Ameyama, F.Cazes, M.Ota, *A three-dimensional multi-scale polycrystalline plasticity model coupled with damage for pure Ti with harmonic structure design*, Int. J. Plasticity, 100, 192-207, 2018.

【Term of Project】 FY2018-2022

【Budget Allocation】 155,000 Thousand Yen

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