【International Leading Research】

Structural Metallic Materials Managing Ultra High Strength and Large Ductility by High-Order Control of Deformation: Fostering Young Researchers with Dual-Sword Skills of Experiments and Computation

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Purpose and Significance of the Research

●Background and Purpose

Only metals show high strength and large plasticity among industrial materials, so that metals and alloys are widely used as safe structural materials in our society. Nowadays ultra-high strength is required to metallic materials for satisfying demands of huge constructions and light-weighting of transportation devices for Carbon-Neutral (Fig.1). However, ductility and toughness are deteriorated when strength increases in all kinds of materials. The present project aims to realize metals and alloys having both ultra-high strength and high toughness/ductility through their nano-structuring.

●Novelty and Interests

Solid metals have crystal structures constructed by periodical alignment of atoms. Metallic crystals are, however, not perfect but include various kinds of lattice defects that make variety of nano/microstructures with a wide range of length scales from several nano-meters (nm) to several tens micro-meters (μm). We have studied Bulk Nano-structured Metals (BNM: Fig.2) composed of grains smaller than 1 μm (=1000 nm) and have found some BNMs exceptionally managing both high strength and large ductility. In such BNMs, dislocation slips are significantly suppressed, while unusual deformation modes are activated, leading to enhancement of strain-hardening. Based on this finding, we propose the strategy to manage both ultra-high strength approaching to ideal strength and large ductility plus toughness through sequentially activating different deformation modes (Fig.3). The international team pursue the fundamental principle of deformation mechanisms by means of the state-of-the-art experimental and computational techniques, for realizing ultimate structural metallic materials .

Fig.1 Demands of huge constructions, light-weighting, and safety.

Fig.2 TEM image of a Bulk Nanostructured Metal

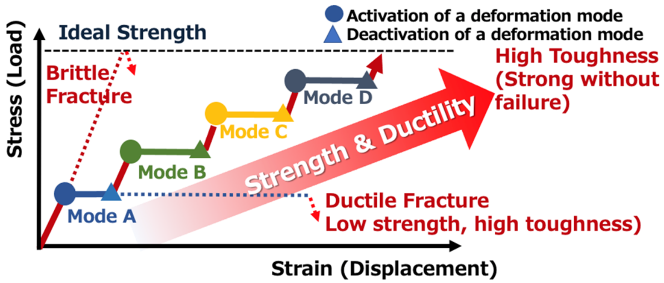

Fig.3 Strategy to manage both high strength and large ductility.

Organization of the Project Team

Figure 4 illustrates the international team of the present project. World-leading scientists in six different organizations (Kyoto Univ., Osaka Univ., UC Berkeley, MIT, Chongqing Univ. and Univ. Lyon) carry out international collaborative works with young researchers for achieving the goal of the current project. Kyoto U, UC-B and CQU conduct experimental works using technologies on materials processing, nanostructure characterizations by advanced electron microscopy, and cutting-edge deformation tests. Osaka U, MIT and U Lyon are in charge of theoretical and computational part using theories of dynamics and the state-of-the-art simulations. The young researchers are the main players of the project. They can experience international collaborations at overseas sites of both experimental and computational studies, to become Dual-Sword talents for next generation of materials science and Engineering.

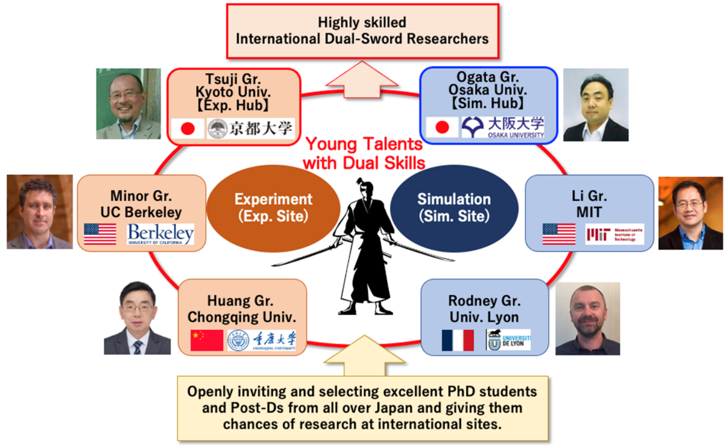

Fig.4 International collaboration team.

Plan for Fostering Early-career Researchers

●Fostering Young Researchers Having Dual-Sword Skills

An important aim of the international leading program is to foster materials scientists in next generation through international joint research. Particularly, the present program tackles to make Dual-Sword talents in both experimental and computational research. We expect that such young talents would change materials science, like Shohei Otani in MLB is changing the concept of baseball. Outline of the Dual-Sword program is shown in Fig.5. PhD students and post-D fellows are openly recruited from Japanese universities through public offering, and they can have chances to make research works on both experimental and computational studies at international sites. Original supervisors of the candidates join the mentor team, and international sites can be added, depending on research subject of the young researchers. PhD students stay abroad for several months ~ 2 years, while post-Ds for 2 ~ 3 years. We plan to send more than 12 young talents for each DC and PD program.

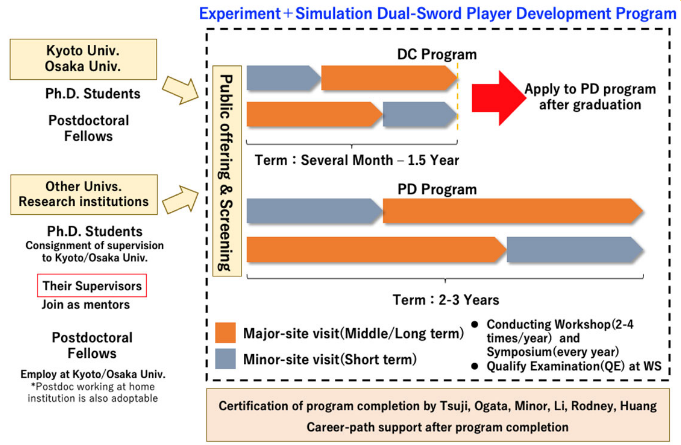

Fig.5 Outline of the Dual-Sword program.

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