本学工学部機械・エネルギーシステム工学科後藤教授らの論文が Advances In Engineering (AIE) により、工学・学術的に特に重要度の高い論文として選ばれ、AIE のサイトにて紹介されました。

後藤真宏教授・山本隆栄助教・北村純一専門職員らの超微細粒材料に関する下記の論文が、注目すべき優れた研究成果として、5 月 30 日、カナダのリサーチ会社 Advances in Engineering （以下 AIE）のホームページに掲載されました。
(https://advanceseng.com/mechanical-engineering/formation-mechanism-inclined-fatigue-cracks-ultrafine-grained-cu-processed-equal-channel-angular-pressing/)

発表論文：
"Formation mechanism of inclined fatigue-cracks in ultrafine-grained Cu processed by equal channel angular pressing ",
M. Goto, SZ. Han, T. Yamamoto, J. Kitamura, JH. Ahan, T. Yakushiji, S. Kim, J. Lee
International Journal of Fatigue, Vol. 89 (2016), IF=2.275, 刷上がり 11 ページ（2016 年 2 月に Web 上で公開され 8 月に掲載予定）

概要：超微細粒材料の傾斜疲労き裂の形成機構を組織学と力学の両視点から解明した。これまで力学的視点から解明した研究の報告例は無く、今後の超微細粒銅の開発と評価を行う際に注目すべき学術上重要な成果である。

ARTICLE IN PRESS

International Journal of Fatigue xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Fatigue

journal homepage: www.elsevier.com/locate/ijfatigue

ELSEVIER

Formation mechanism of inclined fatigue-cracks in ultrafine-grained Cu processed by equal channel angular pressing

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ARTICLE INFO

Article history:
Received 23 November 2015
Received in revised form 1 February 2016
Accepted 2 February 2016
Available online xxxx

Keywords:
Equal channel angular processing
Fatigue crack
Aspect ratio
Copper
Stress intensity factor

ABSTRACT

The formation mechanism of inclined fatigue-cracks in ultrafine-grained Cu processed by equal channel angular pressing was studied by using a partially notched specimen in which a fatal natural crack was introduced, to a specific site of the smooth surface was feasible regardless of microstructural inhomogeneity caused by the processing. The crack growth direction depended on the location along the circumferential direction of the round bar specimen and on the applied stress amplitudes. The role of the microstructure and deformation mode at the crack-tip areas on the formation behavior of fatal cracks is discussed in terms of the microstructural evolution caused by cyclic stressing and the mixed-mode stress intensity factor. The in-plane shear mode deformation at the crack tip assisted the formation of the inclined crack paths and the unique crack face profile.

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1. Introduction

Ultrafine-grain (UFG) materials processed by equal channel angular pressing (ECAP) have attracted much interest in the last 30 years. To date, many investigators have focused on optimizing processing conditions, on determining the underlying microstructural mechanisms, and on the static mechanical properties [1–5]. In the last 15 years, for envisaged structural applications, extensive attention has been paid to the fatigue performance regarding cyclic properties, S–N characteristics, and formation of shear bands (SBs) [6–13].

Actual machine components and structures invariably contain geometrical irregularities, such as fillets, keyways, screw threads, and holes that play an important role as a crack starter. Fatigue cracks are initiated from such stress raisers at a very early fatigue stage and pass rapidly through stress-concentration regions, followed by long-term crack propagation under nominal stress amplitudes. Accordingly, the crack growth behavior should be clarified for the design and maintenance of safe machine components and structures. Many investigators of the growth behaviors of long (millimeter-range) cracks in UFG metals [14–22], have considered the stress intensity factor (SIF) in their discussion, and showed higher growth rates of these cracks in low and medium values of the SIF range and lower growth thresholds.

At a large stress over fatigue limit stress, the crack growth life from an initial size (grain order size) to 1 mm accounted for about 70% of the fatigue life of smooth specimens of many conventional grain-sized metals [23,24], indicating the necessity for studying small-crack growth behavior to estimate the fatigue life of smooth members. It has been shown that the propagation of small cracks is affected by microstructural inhomogeneity, such as grain boundaries (GBs), phase boundaries, and nonmetallic inclusions [25,26]. In materials that were subjected to ECAP, an orientated defect structure was formed with an inclination to extrusion of 26.6° relative to the longitudinal axis [27]. Such microstructural inhomogeneity resulting from ECAP should inevitably affect the behavior of small cracks. In the low-cycle fatigue (LCF) tests of UFG metals, crack paths that were inclined 45° to the loading direction have been commonly observed [11,27,28]. Goto et al. conducted fatigue tests of a round-bar UFG Cu specimen with a small hole as a crack starter, and discussed the physical background of the extension of single LCF cracks considering the deformation mode at the crack tips [29]. In the fatigue process of smooth specimens without an artificial stress raiser, innumerable cracks are initiated over the whole surface, followed by propagation with coalescence and interaction with multiple cracks. However, a few cracks among such innumerable cracks play a major part in the fracture of the

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http://dx.doi.org/10.1016/j.ijfatigue.2016.02.006
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Please cite this article in press as: Goto M et al. Formation mechanism of inclined fatigue-cracks in ultrafine-grained Cu processed by equal channel angular pressing. Int J Fatigue (2016), http://dx.doi.org/10.1016/j.ijfatigue.2016.02.006

International Journal of Fatigue の掲載論文（全 11 ページ）の 1 ページ目

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論文が海外の第三者機関から注目された事は、本研究成果が学術・工学的に極めて重要な研究成果であることを示しています。