マテリアル先端リサーチインフラ利用報告書
ARIM User's Report

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課題データ / Project Data

項目	内容
課題番号 Project Issue Number	23KU0020
利用課題名 Title	Alウィスカの結晶構造と転位組織
利用した実施機関 Support Institute	九州大学 / Kyushu Univ.
機関外・機関内の利用 External or Internal Use	外部利用/External Use
横断技術領域 Cross-Technology Area	計測・分析/Advanced Characterization
重要技術領域 Important Technology Area	次世代ナノスケールマテリアル/Next-generation nanoscale materials
キーワード Keywords	ナノワイヤ、ナノチューブ,電子顕微鏡/ Electronic microscope,ナノワイヤー・ナノファイバー/ Nanowire/nanofiber

利用者と利用形態 / User and Support Type

項目	内容
利用者名（課題申請者） User Name (Project Applicant)	LUDWIG THOMAS HEINRICH
所属名 Affiliation	東北大学大学院工学研究科
共同利用者氏名 Names of Collaborators in Other Institutes Than Hub and Spoke Institutes	
ARIM実施機関支援担当者 Names of Collaborators in The Hub and Spoke Institutes	Maeno Hiroshi
利用形態 Support Type	技術補助/Technical Assistance

利用した主な設備 / Equipment Used in This Project

項目	内容
利用した主な設備 Equipment ID & Name	KU-001：電子分光型超高圧分析電子顕微鏡

報告書データ / Report

概要（目的・用途・実施内容） Abstract (Aim, Use Applications and Contents)	The current study involves the fabrication and characterization of Al whiskers for future application as functional components like sensors in advanced material systems. Tensile strength of Al whiskers is investigated, whereas transmission electron microscope (TEM) observation was conducted to connect the changes in the crystal structure to the observed tensile strength. In order to rule out any influence by ion beam irradiation on dislocation structure within the whiskers, experiments were conducted without prior focused ion beam (FIB) thinning. Furthermore, as the acceleration voltage of common TEMs with 200 KV is insufficient to acquire sharp images of the crystal structure of an Al specimen thicker than 500 nm, a high voltage electron microscope (HVEM) with an acceleration voltage larger than 1000 kV was used to observe tensile tested Al whiskers.
実験 Experimental	3 whiskers were transferred after tensile testing to Mo grids using electron beam hardening glue. The transmission electron microscopes used for observation was model JEM-1300NEF. 1 whisker was non tested and observed for reference, whereas the other two whiskers were tested, but showed different tensile strength.
結果と考察 Results and Discussion	As the atomic structure of the observed whiskers was highly ordered and acceleration voltage was sufficiently high, whiskers even larger than 500 nm could be observed clearly. Also, dislocation contrasts were easily distinguishable. The whole length of the whisker was scanned in the microscope at different incident beam angles to identify the dislocation structure, that has formed as a result of tensile testing in each wire. During observation constant and meticulous adjustment of the focus was of crucial importance, as the whisker was not processed into a thin lamella, and orientation of the whisker on the Mo grid varied with respective location of observation. Due to this circumstance large rotation of the sample within the HVEM chamber was not possible and the weak beam method could not be used. The untested whisker showed hardly any dislocations, emphasizing that the transfer process of the whisker had no major influence on the dislocation structure of the whisker. Both tested whiskers showed only very limited number of dislocation arms and bands, presumably at areas of stress concentration and preferentially at the fracture tip. However, no global distribution of dislocations throughout the whisker was observed. Images of fracture tips of the two whiskers are given in Fig. 1. The whisker of higher tensile strength showed signs of dislocation bands also at areas except the fracture tip, whereas the whisker of lower tensile strength only showed single dislocation arms.
図・表・数式 1 Figures, Tables and Equations 1	Fig. 1(a): Cleavage fracture tip of a whisker observed in the high voltage electron microscope.
図・表・数式 2 Figures, Tables and Equations 2	Fig. 1(b): Necked fracture tip of a whisker observed in the high voltage electron microscope.

その他・特記事項（参考文献・謝辞等） Remarks(References and Acknowledgements)	We thank Mr. H. Maeno for his great, valuable technical support during observation.

成果発表・成果利用 / Publication and Patents

DOI（論文・プロシーディング）[1] DOI (Publication and Proceedings)	Thomas H. Ludwig, Pencil-Shaped Necking of Thick Al Whisker Grown by Stress-Induced Migration and Enhancement of Tensile Strength, *Advanced Engineering Materials*, **26**, (2024). DOI: doi.org/10.1002/adem.202302081
口頭発表、ポスター発表および、その他の論文[1] Oral Presentations etc.	T. H. Ludwig、"Effect of fabrication condition on the tensile strength of Al whiskers grown from passivated Al thin films by stress induced migration" 第30回 機械材料・材料加工技術講演会(筑波),令和5年9月28日.
特許出願件数 Number of Patent Applications	0件
特許登録件数 Number of Registered Patents	0件