Development of Texture-Controlled Bulk-Materials by Combing Rapid-Solidified Fiber/Ribbon Material Elements with Spark Plasma Sintering(SPS)

Y.Furuya*, M.Yokoyama, C.Saito**,T.Okazaki* and M.Omori*****

*: Faculty of Science and Technology, Hirosaki University, Hirosaki 036-8651,Japan
(e-mail: furuya@cc.hirosaki-u.ac.jp)
**:Graduate Student, Hirosaki University
***: IMR,Tohoku University.Sendai,Japan

Abstarct

It has been shown that rapid-solidified (RS) melt-spun fiber/ribbon/foil type samples can have very high performance of the metallic actuator/sensor properties by the authors. However, as for the applications of these sample materials in smart material systems, the developed rapid-solidified samples are thought to be inevitably too small force to move the machines and structures in the engineering field. Then in this paper, we propose one novel material processing technique that can produce the bulk type solid-state actuator/sensor materials by combing the rapid-solidified fiber/ribbon with short time spark plasma sintering/joining (SPS) method

Introduction

It has been shown that rapid-solidified (RS) melt-spun fiber/ribbon/foil type samples can have very high performance of the metallic actuator/sensor properties by the authors.[1] In those studies, it has been reported that the thin foil or very fine fiber sensor/actuator material elements could be produced by changing the rotating speed of rapid-solidification roller of either plane surface type or triangle-tip type. The technique of producing the rapid-solidified (RS) melt-spun fiber/ribbon/foils is shown in **Fig.1** They had strong crystalline texture with fine columnar grains that were uniquely formed during rapid-solidification process as shown in **Fig.2**. As the thermoelastic shape memory alloy (TSMA), TiNiCu alloy foils and fibers with shaper and very non-linear hysteresis with narrow transformation temperature range below 10K were successfully developed up to the present as shown in **Fig.3**. [1]
However, as for the applications of these sample materials in smart material systems, the developed rapid-solidified samples here are thought to be inevitably too small force to move the machines and structures in the engineering field. Then in this paper, we propose one novel material processing technique that can produce the bulk type solid-state actuator/sensor materials by combing the rapid-solidified fiber/ribbon with short time spark plasma sintering/joining (SPS) method. [2]

Experiments and Results

The basic concept of this material processes is shown in **Fig.4** and **Fig.5**. First, we have to make the performs for bulky composite which consist of 1) the stacked layers of RS-ribbons or 2) the crashed RS-fibers by ball-milling as shown in Fig.20. Then, the green-compacted or stacked layers of RS-material

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
00 JUN 2003	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Development of Texture-Controlled Bulk-Materials by Combing Rapid-Solidified Fiber/Ribbon Material Elements with Spark Plasma Sintering(SPS)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Faculty of Science and Technology, Hirosaki University, Hirosaki 036-8651,Japan ; Hirosaki University**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

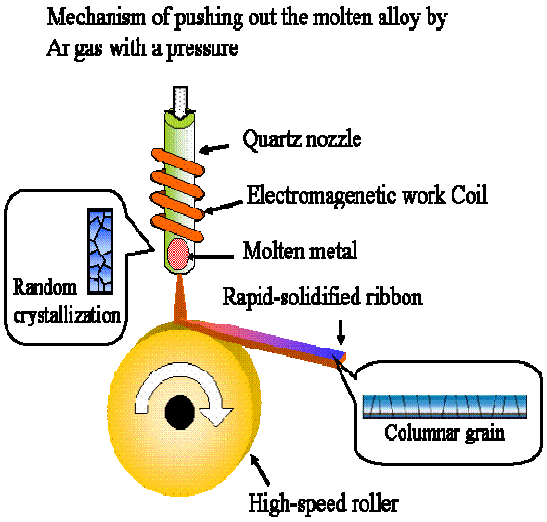
13. SUPPLEMENTARY NOTES
See also ADM001697, ARO-44924.1-EG-CF, International Conference on Intelligent Materials (5th) (Smart Systems & Nanotechnology)., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**4**	

elements are sintered/joined under electric pulse currents with short time within a few minutes in the dies under compressive stresses at high temperature.The schematic figure SPS processing and its features are shown in **Fig.4**.



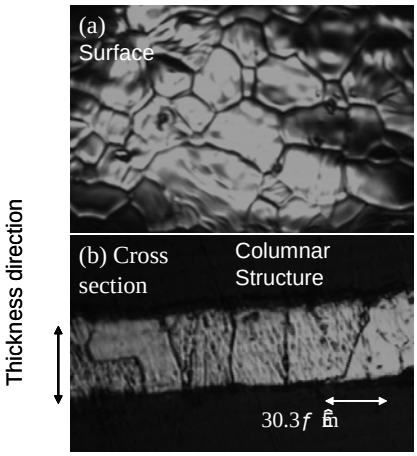
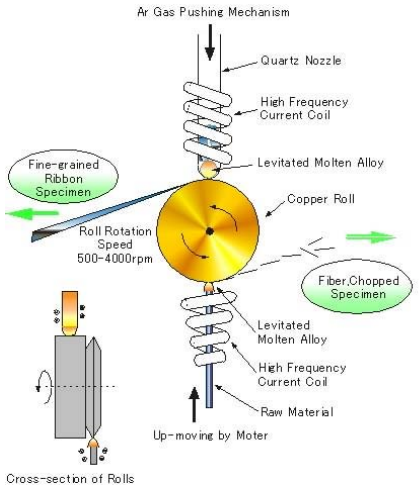


Fig.1(left) The single roll method for producing the rapid-solidified (RS) melt-spun ribbon/foils

Fig.2(right) An example of the clearly developed columnar grains by rapid-solidification.



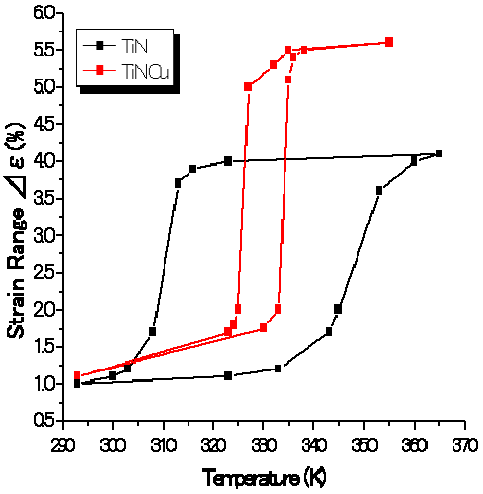


Fig.4 The comparison of narrow and sharp hysteersis of recovery strain vs. temperature relationship in the developed rapid-solidified Ti50Ni40Cu10st% alloy ribbon sample which was produced by our originally developed rapid-solidified (RS) melt-spun fiber/ribbon/foils making machine(left figure).

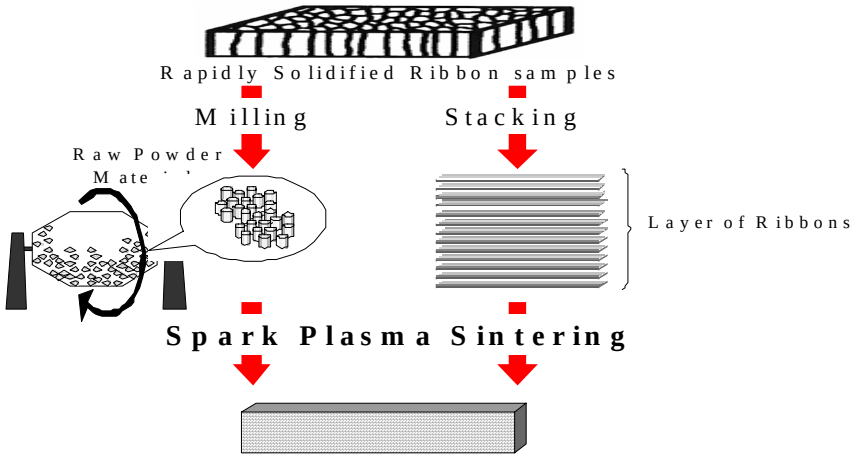


Fig.4 Basic concept of this material process that can produce the bulk type solid-state actuator/sensor materials by combing the rapid-solidified fiber/ribbon with short time spark plasma sintering/joining (SPS).

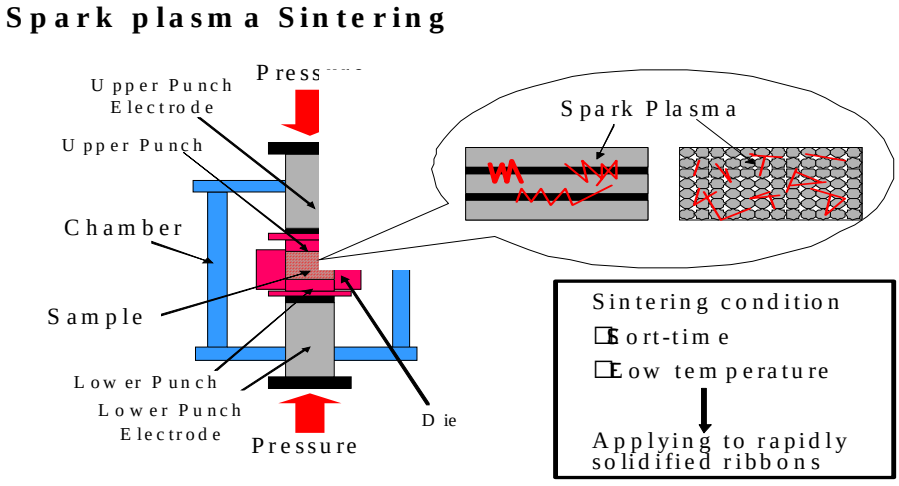


Fig.5 Schematic figure spark plasma sintering/joining (SPS) process and its features in new materials developments

SPS is characterized by producing the high density bulk material as well as short sintering period to suppress the changes of unique fine columnar grains with high performances of RS-samples during heating in the die as well as the formation of brittle interface reacted elements such as oxides as much as possible.**Fig.6** shows the samples which were produced 1) the disk-type sample from stacked layers of RS-ribbons (left photo) and 2)the sintered compact from ball-milled RS-fibers of Ti50Ni40Cu10 alloy. The produced samples showed clear thermoelastic phase transformation by DSC evaluation as well as shape recovery effect as shown in **Fig.7**. These experimental results show us the effectiveness of the proposed, one novel material processing technique that can produce the bulk type solid-state actuator/sensor materials by combing the rapid-solidified fiber/ribbon with short time spark plasma sintering/joining (SPS) method. The same approach is now being tried for making bulky magnetostrictive FeGa alloy systems at Hirosaki University.

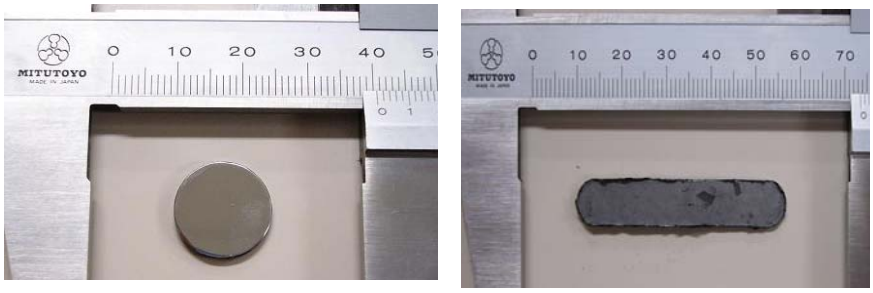


Fig.6 The samples produced 1) the disk-type sample from stacked layers of RS-ribbons (left photo) and 2)the sintered compact from ball-milled RS-fibers of Ti50Ni40Cu10 alloy.

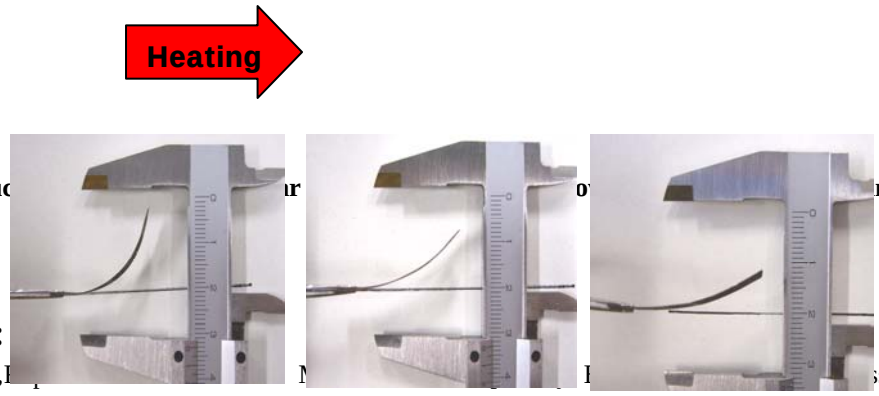


Fig.7 The produc ır o ng.

References:

1.Y.Furuya,2000,I M I ss Melt Spinning Method, Proc.MRS vol.**604**,108-116

2.Y.Furuya,H.Yaguchi,M,Saito,M.Taya,R.Watanabe,1998,Design Mechanical Properties of Smart TiNi Fiber/Al Matrix Composite and its Fracture Process,Proc.ICIM1998(Tokyo),64-67