AFRL-PR-WP-TP-2006-222

TEXTURED COPPER METALLIC SUBSTRATES FOR 2nd GENERATION HIGH TEMPERATURE SUPERCONDUCTOR APPLICATIONS

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JANUARY 2003

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE ***(DD-MM-YY)***
January 2003

2. REPORT TYPE
Conference Paper Postprint

3. DATES COVERED ***(From - To)***
01/02/2002 – 01/02/2003

4. TITLE AND SUBTITLE
TEXTURED COPPER METALLIC SUBSTRATES FOR 2nd GENERATION HIGH TEMPERATURE SUPERCONDUCTOR APPLICATIONS

5a. CONTRACT NUMBER
In-house

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
61102F/62203F

6. AUTHOR(S)
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5d. PROJECT NUMBER
3145

5e. TASK NUMBER
32

5f. WORK UNIT NUMBER
314532Z9

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Power Generation Branch (AFRL/PRPG)
Power Division
Propulsion Directorate
Air Force Research Laboratory, Air Force Materiel Command
Wright-Patterson Air Force Base, OH 45433-7251

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8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-PR-WP-TP-2006-222

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Propulsion Directorate
Air Force Research Laboratory
Air Force Materiel Command
Wright-Patterson AFB, OH 45433-7251

10. SPONSORING/MONITORING AGENCY ACRONYM(S)
AFRL-PR-WP

11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)
AFRL-PR-WP-TP-2006-222

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

13. SUPPLEMENTARY NOTES
Conference paper postprint for the 2003 Fall Materials Research Society Conference Proceedings.

PAO Case Number: ASC 03-3095, 26 Nov 2003.

14. ABSTRACT

Sharp cube textured Cu (100) tapes have been produced as a possible substrate for epitaxially grown conductive, intermediate metallic or ceramic buffer layers with subsequent deposition of high critical current density $YBa_2Cu_30_{7-x}$ (YBCO) films. Cu substrates were fabricated from rods and foils by smooth cold rolling followed by recrystallization. Detailed x-ray diffraction (XRD) studies along with orientation imaging microscopy were performed to measure the inplane alignment, out-of-plane alignment and microtexture for different annealing temperatures. The best full width half-maximum (FWHM) values of 5.4° for in-plane alignment and 5.8° for out-of-plane alignment were obtained at 750°C annealing temperature. Microtexture results indicate more than 97.5% of grains have less than 10° misorientation.

15. SUBJECT TERMS
substrates, high temperature superconductor, YBCO, textured copper substrates

16. SECURITY CLASSIFICATION OF:

a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	**17. LIMITATION OF ABSTRACT:**	**18. NUMBER OF PAGES**
Unclassified	Unclassified	Unclassified	SAR	10

19a. NAME OF RESPONSIBLE PERSON (Monitor)
Paul N. Barnes

19b. TELEPHONE NUMBER *(Include Area Code)*
N/A

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

Mat. Res. Soc. Symp. Proc. Vol. EXS-3© 2004 Materials Research Society

Textured Copper Metallic Substrates for 2nd Generation High Temperature Superconductor Applications

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ABSTRACT

Sharp cube textured Cu (100) tapes have been produced as a possible substrate for epitaxially grown conductive, intermediate metallic or ceramic buffer layers with subsequent deposition of high critical current density $YBa_2Cu_3O_{7-X}$ (YBCO) films. Cu substrates were fabricated from rods and foils by smooth cold rolling followed by recrystallization. Detailed x-ray diffraction (XRD) studies along with orientation imaging microscopy were performed to measure the in-plane alignment, out-of-plane alignment and microtexture for different annealing temperatures. The best full width half-maximum (FWHM) values of 5.4° for in-plane alignment and 5.8° for out-of-plane alignment were obtained at 750°C annealing temperature. Microtexture results indicate more than 97.5% of grains have less than 10° misorientation.

INTRODUCTION

The past several years have shown significant progress in metallic tape development for high J_c superconducting films. Rolling assisted biaxial textured substrates (RABiTS) process has been a successful route for inducing both in-plane and out-of-plane alignment in textured metallic substrates which acts as an architecture for epitaxially grown buffer layers and subsequent YBCO films[1]. Initially, textured YBCO films were deposited on polycrystalline nickel based alloys using yttrium stabilized zirconia (YSZ) as an intermediate buffer layer. Recent studies show interests in cube textured (100) nickel [2] and nickel based alloys such as Ni-Cu[3], Ni-Cr[4], and Ni-V[5]. These materials are proving successful for high Jc value coated conductors utilizing deposition techniques such as sputtering, ion beam evaporation, chemical vapor deposition and pulsed laser deposition. For practical applications, an alternate metallic substrate that is non magnetic for low AC losses and conductive for thermal and electrical quench protection is much preferred. Textured metallic substrates based on copper meet the above requirements due to ease of achieving sharp cube texture and the non-magnetic and highly conductive nature of the material. The present work involves the fabrication of highly textured metallic copper substrates using the rolling-assisted biaxially textured substrate (RABiTS) technique.

EXPERIMENTAL DETAILS

Substrates were created using 99.99% purity grade copper extruded rods with an initial thickness 9.5mm and rolled foils with an initial thickness of 2.0mm. The rods were partially flattened to 7.5mm creating two parallel faceted surfaces in the axial direction using a uniaxial forge press at 116 tons. The flat surfaces of the rods and foils were ground and polished to a

6μm diamond finish. The final thicknesses were 6.92mm for the rod and 1.86mm for the copper foil after polishing. Cold work was removed from both materials by annealing at 450˚C for 1 hour.

Reverse cold rolling in steps of 10% reduction per pass was performed producing four deformation levels. A sample at each deformation level was subjected to varying annealing temperatures in a (Ar/H_2 5%) partial pressure environment. The deformation levels, thicknesses and annealing schedule for the copper rod and copper foil can be seen in table 1.

Copper Rod & Copper Foil					
Reduction (%)	**97.00%**	**98.00%**	**99.00%**	**99.50%**	**Duration (h)**
Rod Thickness (μm)	175	128	67	36	N/A
Foil Thickness (μm)	58	39	20	10	N/A
Annealing Temp (ºC)	As Rolled	As Rolled	As Rolled	As Rolled	N/A
	300	300	300	300	6
	500	500	500	500	1
	550	550	550	550	1
	600	600	600	600	1
	650	650	650	650	1
	700	700	700	700	1
	750	750	750	750	1
	800	800	800	800	1

Table 1. Annealing schedule for the copper rod and copper foil at each deformation level. A back pressure of 2-6μTorr and a partial pressure of (Ar/H_2 5%) at 200mTorr were used.

Recrystallization texture presence was determined using coupled 2θ XRD, while in-plane and out-of-plane alignment was measured using Φ, and Ψ scan XRD, and microtexture was characterized utilizing Orientation Imaging Microscopy (OIM).

DISCUSSION

Copper Foil

There was no trend or predominant peaks seen in the (110) deformation texture 2θ scans even at 99.5% deformation. Minimal (100) recrystallization texture presence was seen in the annealed samples; where a 750ºC annealing temperature revealed the best 2θ scan but predominant peak intensities were weak.

Copper Rod

(110) deformation texture is seen in the as rolled samples with a diverging trend between the predominant and secondary peaks for increasing levels of deformation (see figure 1.). Sharp cube (100) recrystallization texture was developed in the 750ºC annealed samples as seen in figure 2. The Φ scan and Ψ scan full width half maximum (FWHM) values of 5.4º and 5.8º can be seen in figure 3. Recrystallization at 750ºC indicates minimal differences in the FWHM values for samples between 97% and 99.5% deformation (see figure 4.). OIM microtexture results reveal more than 97.5% of grains with <10º misorientation while retaining no fraction of twinning (see figures 5 & 6.). As seen in figure 6, SEM micrographs show a stable equiaxed

grain structure at 750ºC with no observable twinning. Results show that all of the heavily deformed rod samples produced sharp (100) macrotexture but subsequent OIM data revealed weak microstructure.

Figure 1

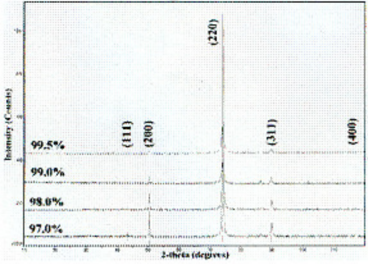

Figure 2

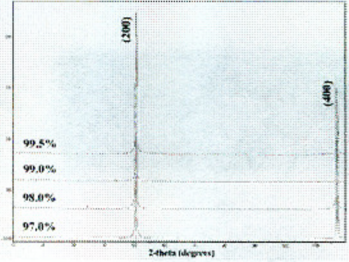

Figure 3

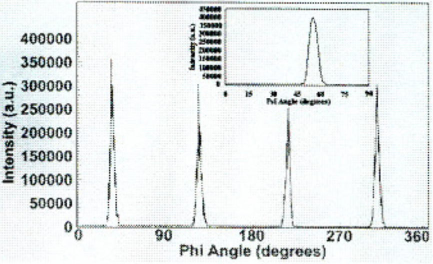

Figure 1. (110) Deformation texture for as rolled sample at increasing levels of deformation.
Figure 2. (100) Recrystallization texture for samples annealed at 750ºC.
Figure 3. Φ scan and Ψ scan FWHM values of 5.4° and 5.8° for 750ºC annealing temperature.

Figure 4

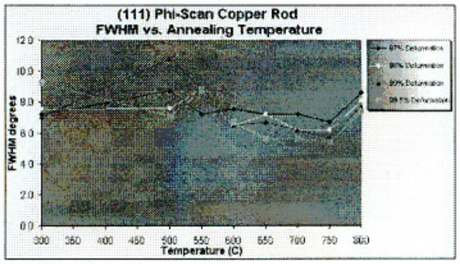

Figure 5

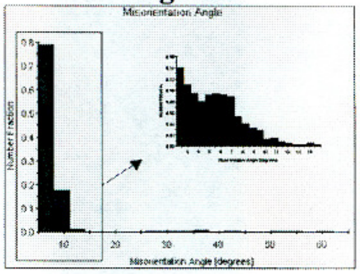

Figure 6

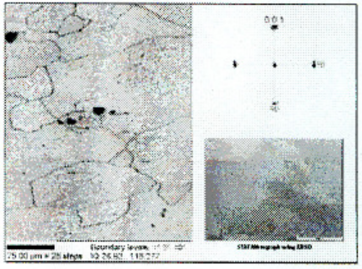

Figure 4. Φ scan FWHM vs. annealing temperature at each deformation level.
Figure 5. OIM data revealing more than 97.5% of grains with <10° misorientation.
Figure 6. OIM and SEM images and 001 pole figure for 750ºC annealing temperature.

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