



W. W. Hansen Experimental Physics Laboratory
STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305 - 4085

Gravity Probe B Relativity Mission

History of Niobium Targets in Rotor Coating System

S0651, Rev. -

March 15, 2002

Approved and Prepared by:

Dale Gill 4/17/02

Dale Gill

Approved by:

Rob Brumley 4/19/02

Rob Brumley

Approved by:

Anthony Logan 4/16/02

Anthony Logan

ITAR Assessment Performed

Tom Langerstein

Tom Langerstein

ITAR Control Req'd? ☐ Yes ☒ No

4/22/02

Purpose:

To provide a history of the niobium targets in Rotor Coating System using documents that certifies the material quality and the acquisition of the material.

History:

There have been three niobium targets installed in the MRC rotor coating system since the system was transferred to Stanford University from MSFC in March 1987.

The first target was purchased from Sputtering Materials, Inc. in June of 1988. It was 99.9% Nb target with a Resistance Ratio > 100. The purchase order number was U3XD 9717640. See Figure 1. Certification and Figure 2 Removed target with label.

The remaining two targets were made from material purchased from Teledyne Wah Chang Albany by Stanford University in November 1992 on P.O. C3RD C67673. Target disks were machined from this material by the Stanford Physics machine shop in November 1992. Sputtering Materials, Inc. bonded the target disks to the target backing plates in December 1992 and February 1993. These targets were installed in the MRC sputtering system in position #1 on 2/19/93 and position #4 on 2/22/93. The target in position #4 was used for coating rotors beginning 10/11/96 and continuing through all flight rotor production.

Attachments:

The attached scanned documents are as follows:

- Figure 3: Pre-Requisition for Niobium sheet material from Teledyne Wah Chang.
- Figure 4: Mechanical Components Order Checklist
- Figure 5: Packing List for niobium sheet material from Teledyne Wah Chang.
- Figure 6: Ingot Analysis for niobium sheet material from Teledyne Wah Chang.
- Figure 7: Drawing for target machining at Physics Machine Shop
- Figure 8: Pre-Requisition for Bonding target 11/92
- Figure 9: Purchase Order for Bonding Target.
- Figure 10: Return Material form for bonding target.
- Figure 11: Pre-Requisition or Bonding target 2/93
- Figure 12: Bag Labels for Bonded targets.

**CERTIFICATE OF
ANALYSIS AND COMPLIANCE**

CUSTOMER: STANFORD UNIVERSITY
HANSEN LABORATORIES
STANFORD, CA 94305

PURCHASE ORDER NO: U3XD 9717640 RELEASE NO: 1

MATERIAL COMPOSITION: NIOBIUM

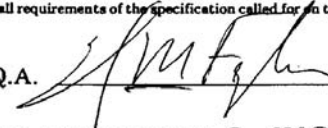
PURITY/GRADE: 99.9%

PART NO: N/A LOT NO: 2884/5316

DESCRIPTION: NIOBIUM SPUTTERING TARGET
RESISTANCE RATIO: >100
DIMENSIONS: 6" DIAMETER x 1/8" THICK

ACTUAL ☒		ELEMENTAL COMPONENTS		TYPICAL ☐	
(In Parts Per Million)					
Al	<20	B	<1	C	<30
Ca	<20	Cd	<5	Co	<10
Cr	<20	Cu	<40	Fe	<50
Hf	<50	Mg	<20	Mn	<20
Mo	<50	Ni	<20	O	<50
P	<25	Pb	<20	Si	<50
Sn	<10	Ta	970	Ti	<40
V	<20	W	<70	Zr	<100

This is to certify that all work done, materials and/or processes furnished or performed are in accordance with our normal process controls, and meet all requirements of the specification called for in this purchase order and referenced blueprints.

Date: 23 June 1988 Q.A. 

SPUTTERING MATERIALS, INC.

Sputtering Target Bonding Service / High Purity Targets

473 SAPENA COURT, SUITE 23
SANTA CLARA, CA 95050
(408) 727-5671

Figure 1. Certification

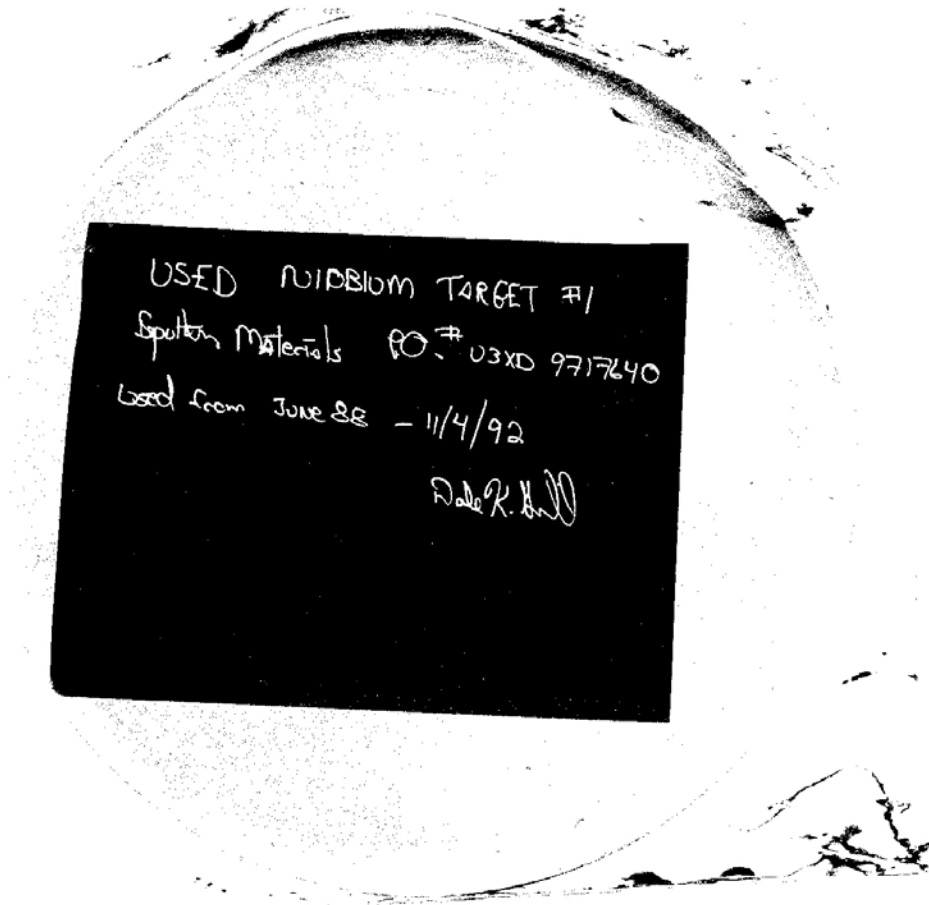


Figure 2. Removed target with label



PRE-REQUISITION

[] DO NOT OPEN
[] DO NOT TOUCH
[] TAG CABINET ONLY

THIS WORKSHEET IS TO BE COMPLETED AND TURNED IN TO THE HANSEN REQUISITION DESK (Ginzton Room 25 Tel 723-0211)

FUND NO:	ACCOUNT NO: 2WHK628 Item #5	TAXABLE? [] YES [] NO	CONTRACT/GRANT/ACCOUNT NO.	DELIVERY: [] Hansen Labs [] Bonair	
REQUESTOR: D. G. [Signature]	TELEPHONE EXT: 5-2216	RETURN PAPERWORK TO: Hansen Labs @ Ginzton Rm 25	DATE WRITTEN: 11/6/92	DATE REQUIRED: 11/10/92	
CODE	ITEM #	DESCRIPTION (Model Number, Catalogue Number)	QTY & UNIT	UNIT COST	EXTENDED EST
	1	Niobium Sheet Pure RRR Grade .124 thick 24.75" x 28.75" (27.40 lbs) 0.0122/lb	27.41 lbs	\$122.00	\$3342.80
SUGGESTED VENDOR			BLOG and ROOM NO.	P.I. or GROUP AFFIL	
Teledyne Wah Chang Albany PO. Box 460 Albany, OR 97321			STE FABRICATION NUMBER:		
[] Estimate as of last purchase [] Catalogue price [] Written quote (Attach copy) [] Telephone quote (Cite Name/Number) (503) 926-4211			EXPENSE CLASS CODES UNIV AGENCY		Expendable Materials/Suppl 611 []
			Scient/Tech Equip 421 [] 441 []		Scient/Tech Minor Equip 622 []
			Gen'l Purpose Equipment 428 [] 448 []		Gen'l Purpose Minor Equip 623 []
			STE Components 426 [] 446 []		Expendable: Mark/Engrave 682 []
			Office Machines 429 [] 449 []		Maint/Repair Univ Owned 368 []
			Computer Equipment 427 [] 447 []		Maint/Repair Agency Owned 367 []
			EXCEPTIONS WILL BE LISTED IN CODE COLUMN		Other []
REMARKS: Bob Kenny ↓ see memo - Customer Service			REQUESTOR PLEASE NOTE:		
			If so required on this contract, did you attempt to locate a "SMALL or DISADVANTAGED BUSINESS" Concern? YES [] NO []		
			Do you recommend that this item be classified as EQUIPMENT? YES [] NO []		
			If so, will there be a problem in placing a property-tag on the item? YES [] NO []		
If there are any critical instructions for Receiving Personnel, please enter them in the REMARKS Section of the form.					

Figure 3 Pre-Requisition for Niobium sheet material from Teledyne Wah Chang.

Mechanical Component Order Checklist

(To be filled by design engineer)

1. Description of component / system: Niobium Sheet, Pure RRR Grade .125
for Sputtering Target Fabrication
2. Standard component (SC) or Built to drawing (BTD)? SC
3. Catalog No: none
4. To meet Spec. No: Niobium Pure Grade RRR
Rev
5. If BTD, attached is drawing No: Rev
6. List preferred vendors
Teledyne Wah Chang Albany
7. Sole vendor? Y/N Y
8. Past experience with vendor? Y/N Y
9. Quality requirements:
Method of acceptance by:
 - a. Vendor Certificate of conformance (COC): (standard components only) State Yes
with copy of Lot Analysis
 - b. By vendor detailed Inspection Report (IR): (BTD components) State Yes
 - c. Acceptance testing at Stanford/ Lockheed/ independent lab State Yes
(IR is attached for inspector use)

Remarks:

- a. Standard components to be purchased from QPL source.
- b. For BTD systems, detailed inspection requirements to be included in spec. or attached to drawing.

Figure 4. Mechanical Components Order Checklist

TO
ADDRESS
STANFORD UNIVERSITY
P.O. Box 4409
Stanford, CA 94309

ATTENTION OF: Purchasing Agent

TELEDYNE
WAH CHANG ALBANY

P.O. BOX 460
ALBANY, OREGON 97321-0136
(503) 926-4211 TWX (510) 595-0973

IN REGARD TO YOUR
PURCHASE ORDER NO. C67673
ITEM NO. 1
DESCRIPTION Nb RRR Strip
DIMENSIONS .124" x 24.75" x 28.75"
SPECIFICATIONS Per Purchase Order

DATE Nov. 18, 1992
DATE SHIPPED Ref. P.L.#
QUANTITY SHIPPED 1 pc.
WEIGHT SHIPPED 28.6 lbs.
SALES ORDER NO. 5155
HEAT NO. 502140 Nb
PACS NO. 12603

THE TEST REPORT FOLLOWS:

INGOT ANALYSIS IN PPM

Element	1	2	3	4	5
Al:	<20	<20	<20	<20	<20
B:	<1	<1	<1	<1	<1
C:	<20	<20	<20	<20	<20
Ca:	11	11	10	11	<10
Cd:	<5	<5	<5	<5	<5
Co:	<10	<10	<10	<10	<10
Cr:	<20	<20	<20	<20	<20
Cu:	<10	<10	12	<10	<10
Fe:	<35	<35	<35	<35	<35
H:	<5	---	---	---	<5
Hf:	<20	<20	<20	<20	<20
Mg:	<10	<10	<10	<10	<10
Mn:	<20	<20	<20	<20	<20
Mo:	<30	<30	<30	<30	<30
N:	11R, <5R	---	---	---	12R, 12R
Ni:	<20	<20	<20	<20	<20
O:	<50R, <50R	---	---	---	<50R, 60R
Pb:	<20	<20	<20	<20	<20
Si:	<25	<25	<25	<25	<25
Sn:	<10R	<10R	<10R	<10R	<10
Sr:	<10R	<10R	<10R	<10R	
Ta:	130	120	120	150	150
Ti:	19	14	13	12	12
V:	<20	<20	<20	<20	<20
W:	<30	<30	<30	<30	<30
Y:	<2	<2	<2	<2	<2
Zr:	32	29	28	30	29

INGOT RESIDUAL RESISTIVITY RATIO: TEST

Spec.: 250 min.
Room Temp/LHe 353
Ice/LHe 334

MATERIAL
CERTIFIED BY
mw

Tony Nelson 11-18-92
Tony Nelson
Quality Assurance Dept.

A1.04.01.18 P1-1
C1.04.17.23

Figure 6 Ingot Analysis for niobium sheet material from Teledyne Wah Chang.

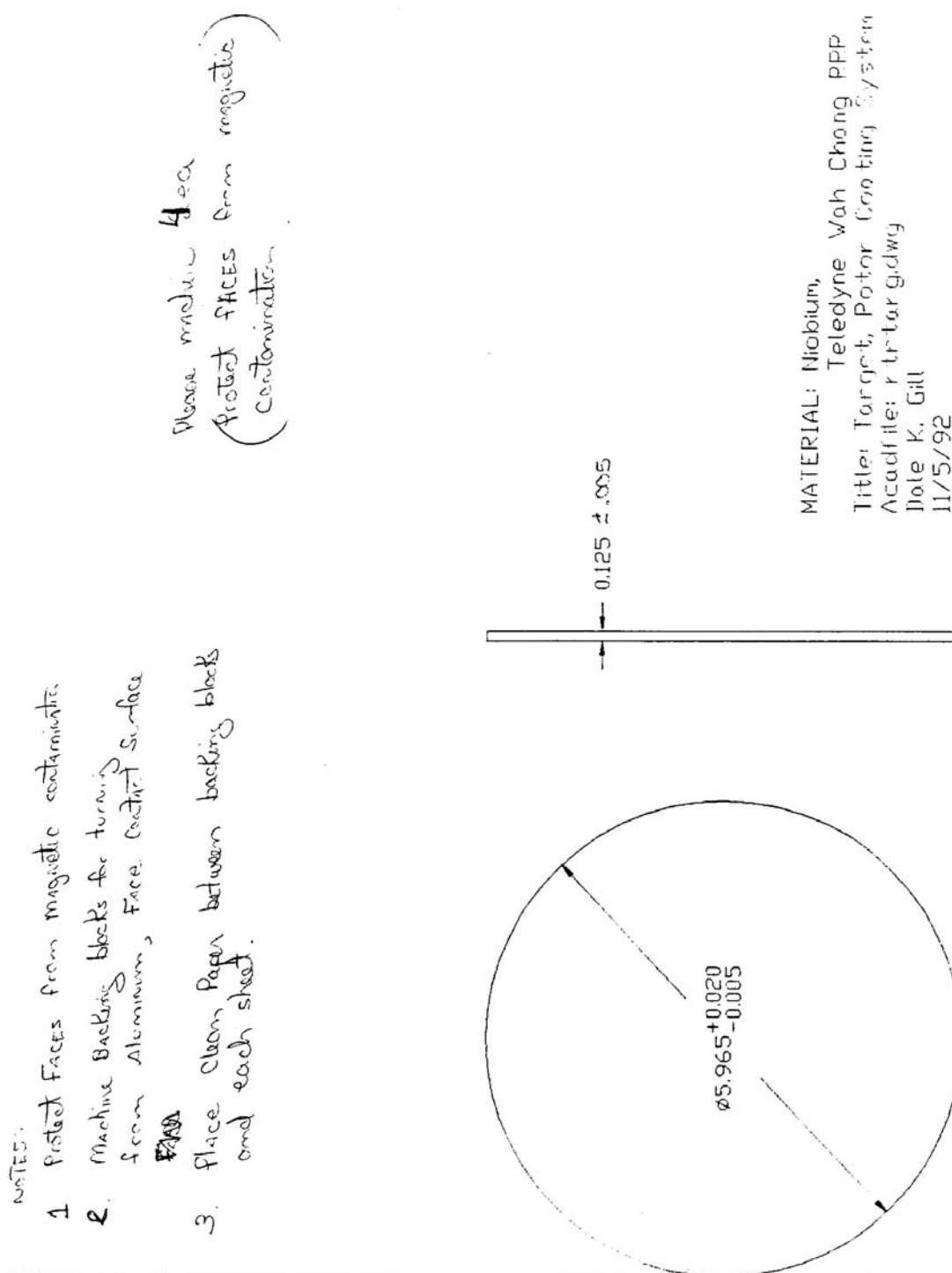


Figure 7 Drawing for target machining at Physics Machine Shop



W.W. HANSEN EXPERIMENTAL PHYSICS LABORATORY

PRE-REQUISITION

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THIS WORKSHEET IS TO BE COMPLETED AND TURNED IN TO THE HANSEN REQUISITION DESK (Ginzton Room 25 Tel 723-0211)

FUND NO:		ACCOUNT NO: SWHE628 IN 25	TAXABLE? ☐ YES ☐ NO	CONTRACT/GRANT/ACCOUNT NO.		DELIVERY: ☐ Hansen Labs ☐ Bonair			
REQUESTOR: D. G. Q.		TELEPHONE EXT: 5 2216	RETURN PAPERWORK TO: Hansen Labs @ Ginzton Rm 25		DATE WRITTEN: 11/6/92	DATE REQUIRED: 12/4/92			
CODE	ITEM #	DESCRIPTION (Model Number, Catalogue Number)				QTY & UNIT	UNIT COST	EXTENDED EST	
	1	Bond Niobium target to MRC backing plate. Remove existing used target (Return if possible). refurbish backing plate and bond new target. Standard to supply used backing plate and new Niobium target.				1 ea	\$425.00		
		Received 12/9/92 w/o old target material Discussed with Cliff Purdy 12/9/92, he'll ship.							
SUGGESTED VENDOR Sputtering Materials, Inc. 816 Chancery Ave. San Jose, CA 95131			BLDG and ROOM NO. P.I. or GROUP AFFIL			SUBTOTAL			
☐ Estimate as of last purchase ☐ Catalogue price ☐ Written quote (Attach copy) ☒ Telephone quote (Cite Name/Number)			STE FABRICATION NUMBER:			SALES TAX			
						TOTAL			
			EXPENSE CLASS CODES UNIV AGENCY Scient/Techn Equipment 421 ☐ 441 ☐ Gen'l Purpose Equipment 428 ☐ 448 ☐ STE Components 426 ☐ 446 ☐ Office Machines 429 ☐ 449 ☐ Computer Equipment 427 ☐ 447 ☐ EXCEPTIONS WILL BE LISTED IN CODE COLUMN Other ☐			Expendable Materials/Suppl 611 ☐ Scient/Techn Minor Equip 622 ☐ Gen'l Purpose Minor Equip 623 ☐ Expendable: Mark/Engrave 682 ☐ Maint/Repair Univ Owned 368 ☐ Maint/Repair Agency Owned 367 ☐			
REMARKS: Cliff Purdy (408) 954-1280 Fax (408) 954-1284			REQUESTOR PLEASE NOTE:						
			If so required on this contract, did you attempt to locate a "SMALL or DISADVANTAGED BUSINESS" Concern? YES ☐ NO ☐						
			Do you recommend that this item be classified as EQUIPMENT? YES ☐ NO ☐						
			If so, will there be a problem in placing a property-tag on the item? YES ☐ NO ☐						
If there are any critical instructions for Receiving Personnel, please enter them in the REMARKS Section of the form.									

Figure 8 Pre-Requisition for Bonding target 11/92

CREDIT NO.	1ST ACCOUNT	ACCOUNT NAME	Taxable Acct?	Items?	DEPARTMENT
18HE001	2-WHE628-94446	HAS 8-36125	[X] Yes	[X] No	HANSEN LABS

STANFORD UNIVERSITY	
Rapid Purchase Order	Not valid for more than \$1,000 (including tax)

133944
SPUTTERING MATERIALS IINC
816 CHARCOT DRIVE
SAN JOSE, CA 95131

See Instruction A below

(SI) DALE GILL
(H) P.O. RM6409
(I) HANSEN LABS
(P) HANSEN LABS, VIA PALOU ST., GP-B
(T) STANFORD, CA 94305-4085
(O)

F.O.B.: Ship. Destl-Ship Via Delivery Date Terms: % Days Net
[X] point [] nation Vendor ASAP | 0.00 | 30

ORDER PLACED WITH
CLIFF PURDY 408-954-1280

DESCRIPTION

1 BOLD NIUBIUM TARGET TO MRC BACKING PLATE, REMOVE EXISTING USED TARGET (RETURN IF POSSIBLE) refurbish backing plate and bond new target. Stanford to supply used backing plate and new niubium target.

PLEASE CONFIRM PRICE AND DELIVERY DATE

Quant	Unit	Price	Ext.	Price
1	EA	425.00		425.00

SPECIAL INSTRUCTIONS
Contact Filly @ 415-725-0602

[X] CA Tax exempt, Permit # SR-GH-26-001337. Not valid if Total, including tax, is more than \$1,000 --> TOTAL | 425.00

DIRECT QUESTIONS TO:
CAROLYN C KAYE
415-723-7548

ISUBTOTAL | 425.00
ISALESTAX | .00

Carolyn Kaye

INSTRUCTIONS
A. Invoices: In triplicate. Separate invoices for each purchase order. Show P.O. number on all documents. Mail to Stanford University, P.O. Box 4409, Stanford, CA 94309-4409.
B. Correspondence: Mail to the 'Ship To' address shown above.

C. Transportation: Do not ship collect. Prepay and state freight separately on invoice. Show Purchase Order number on outside of each container.
D. Late Shipment: Advise at once if order will not reach destination on time.
E. Terms and Conditions: This Purchase Order is subject to Stanford University's standard terms and conditions which will be furnished upon request.

Figure 9 Purchase Order for Bonding Target.

W.W. HANSEN LABORATORIES OF PHYSICS
REQUEST TO RETURN MATERIAL

DATE 12/1/92

REQUISITION NO. RN6409 REQUESTOR NAME AND PHONE EXT. DALE GILL 5-2216
 VENDOR NAME SPUTTERING MATERIALS, INC. PHONE NO. (408) 954-1280 PACKING SLIP ATTACHED? NO
 VENDOR ADDRESS 816 CHARCOT DRIVE SAN JOSE, CA 95131 ITEM NO. ON REQUISITION 1
 ITEM MODEL NO. N/A SERIAL NO. N/A H.L. PROPERTY NO. N/A
 ITEM(S) AS ORDERED N/A
 ITEM(S) AS RECEIVED AND REASON FOR RETURN:
 MATERIAL DEFECTIVE? N/A
 MATERIAL NOT AS ORDERED? N/A
 OVERSHIPMENT OF MATERIAL? N/A
 WARRANTY REPAIR? N/A
 OTHER REFURBISHING BOND NIOBIUM TARGET BACKING PLATE AND BOND NEW TARGET.

HAS VENDOR BEEN CONTACTED? YES CONTACT'S NAME CLIFF PURDY RETURN AUTHORIZATION NO. N
 RETURN FOR CREDIT? N/A REPLACEMENT/EXCHANGE N/A REPAIR N/A OTHER REFURBISHING
 RETURN SHIPMENT VIA STANFORD TRAFFIC DEPARTMENT NO ITEM(S) IN H.L. RECEIVING YES
 OTHER METHOD(S) OF SHIPMENT UPS SHIPPING INSTRUCTIONS? REGULAR
 LIST INSURED VALUE N/A DIMENSIONS (IF APPLICABLE) _____
 EST. WEIGHT _____ LOCATION _____ ADD'L SPECS. _____

-----FOR OFFICE USE ONLY-----

ACCOUNT NUMBER & CODE 2WHE628-94446 ACCOUNT TITLE NAS8-36125
 PURCHASE ORDER NO. RN6409 STE NO. 0511
 SIGNATURE OF DELIVERY PERSON (IF PICKED UP BY S.U. TRAFFIC DEPT.) _____
 (PICK-UP POINT-HANSEN LABS. RECEIVING) DATE _____
 SIGNATURE OF VENDOR REP. (IF HAND-CARRIED/MAILED, ETC. TO VENDOR) [Signature]
 DATE 12/1/92
 COMPLETION DATE (I.E. DATE RETURNED THROUGH H.L. RECEIVING, OR DATE RETURNED FROM VENDOR):
 DATE _____

HAVE ITEM(S) BEEN SATISFACTORILY REPLACED, REPAIRED, CREDITED, ETC? _____

ADDITION NOTES/REMARKS: cc: DALE GILL COMMIT FILE (C. KAYE)
 MIKE KILLIAN ACCOUNTS PAYABLE
 PETE CRUZ

Figure 10 Return Material form for bonding target.



W.W. HANSEN EXPERIMENTAL PHYSICS LABORATORY

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FUND NO:		ACCOUNT NO: 20HE628 ITEMS	TAXABLE? ☐ YES ☐ NO	CONTRACT/GRANT/ACCOUNT NO.		DELIVERY: ☐ Hansen Labs ☐ Bonair	
REQUESTOR: D. Gell-		TELEPHONE EXT: 5-2216	RETURN PAPERWORK TO: Hansen Labs @ Ginzton Rm 25		DATE WRITTEN: 2/11/93	DATE REQUIRED: 2/26/92	
CODE	ITEM #	DESCRIPTION (Model Number, Catalogue Number)			QTY & UNIT	UNIT COST	EXTENDED EST
	1	Bond Niobium target to MRC backing plate. Remove existing used target (return); refurbish backing plate and bond new niobium target (new target supplied by Stanford).			1 ea	\$425.00	
		Received 2/18/93					
SUGGESTED VENDOR Sputtering Materials Inc. 816 Charcot Ave. San Jose, CA. 95131				BLDG and ROOM NO. P.I. or GROUP AFFIL		SUBTOTAL	
☒ Estimate as of last purchase ☐ Catalogue price ☐ Written quote (Attach copy) ☐ Telephone quote (Cite Name/Number)				STE FABRICATION NUMBER:		SALES TAX	
						TOTAL	
EXPENSE CLASS CODES UNIV AGENCY Expendable Materials/Suppl 611 ☐ Scient/Tech Equip 421 ☐ 441 ☐ Scient/Tech Minor Equip 622 ☐ Gen'l Purpose Equipment 428 ☐ 448 ☐ Gen'l Purpose Minor Equip 623 ☐ STE Components 426 ☐ 446 ☐ Expendable: Mark/Engrave 682 ☐ Office Machines 429 ☐ 449 ☐ Maint/Repair Univ Owned 368 ☐ Computer Equipment 427 ☐ 447 ☐ Maint/Repair Agency Owned 367 ☐ EXCEPTIONS WILL BE LISTED IN CODE COLUMN Other ☐							
REMARKS: Cliff Purdy (408) 954-1280 FAX (408) 954-1284				REQUESTOR PLEASE NOTE: If so required on this contract, did you attempt to locate a "SMALL or DISADVANTAGED BUSINESS" Concern? YES ☐ NO ☐ Do you recommend that this item be classified as EQUIPMENT? YES ☐ NO ☐ If so, will there be a problem in placing a property-tag on the item? YES ☐ NO ☐			
If there are any critical instructions for Receiving Personnel, please enter them in the REMARKS Section of the form.							

Figure 11 Pre-Requisition or Bonding target 2/93

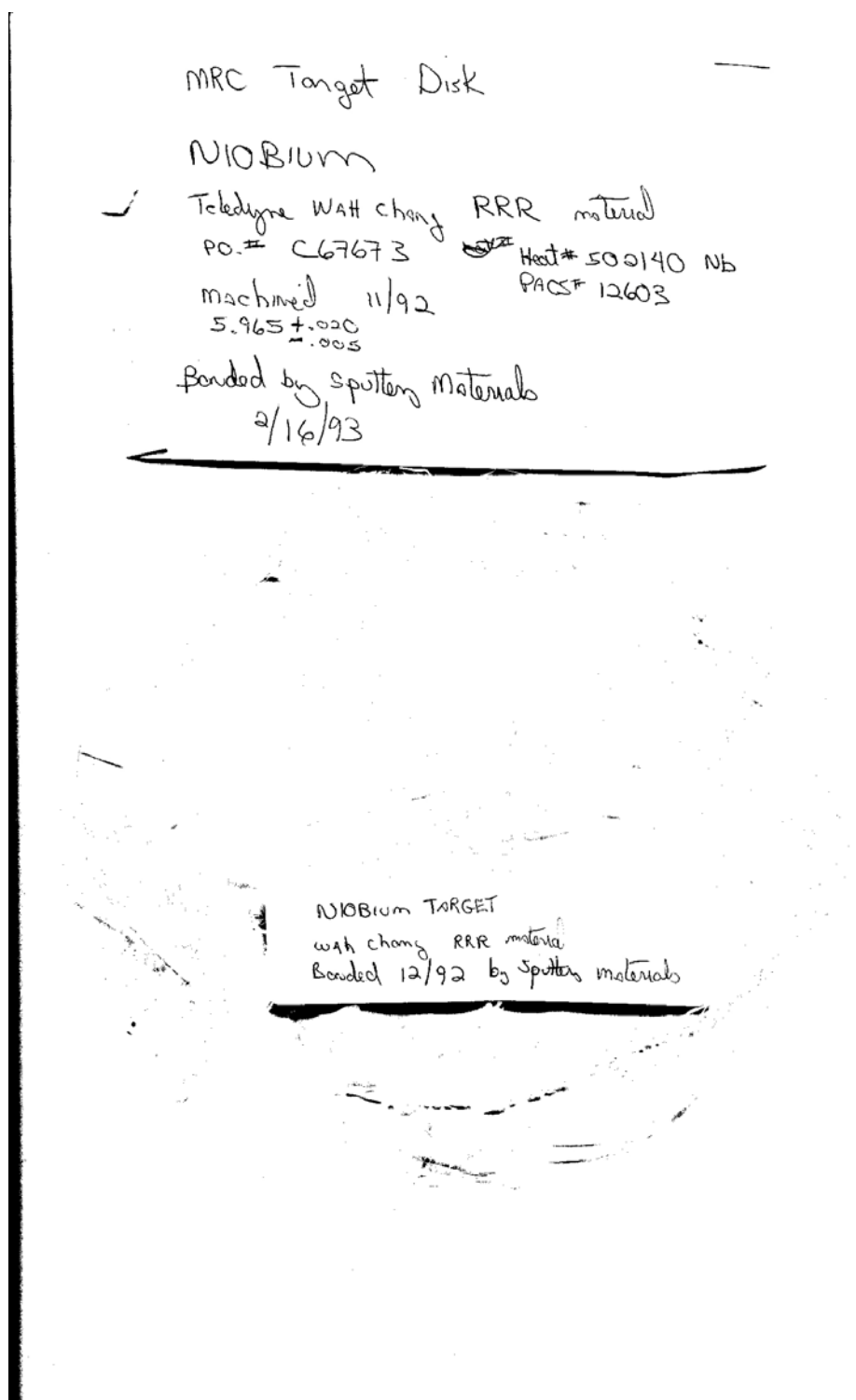


Figure 12 Bag Labels for Bonded targets.