



THE COST LEVEL

N. S. S. S. M.

EPPEREZ (UNIVERSITY)

228888 C

E

MICROCOPY RESOLUTION TEST CHART

	DEPURT DUCUN	IENTATION PAG			
A REPORT SECURITY UNDERDOUT	LU	ID. HESTRICTIVE	MARKINGS		
	MIC	3. DISTRIBUTION	AVAILABILITY C	OF REPORT	
	PECTER	7	distrib <b>uti</b>	or pic for-	
1D-4125 220 4	MR 6=0 1988	5. MONITORING O	RGANIZATION R	EPORT NUMBER	(\$)
		AFOSR-T	<b>R- 88-</b>	បខ្លួមឥ	
64 NAME OF PERFORMING ORGANIZATION State University of New York/ Stony Brook	b. DICE SYMBOL Deplicable)	7. NAME OF MON Air Force Of	TORING ORGAN fice of Sci	entific Res	search
6. ADDRESS (City. State and ZIP Code)		76. ADORESS (City,	Stem and ZIP Co. f the Air F	de)	
Stony Brook, NY 11794		Bolling Air	Force Base,	DC 20332-6	448
Air Force Office of Scientific Air Force Office of Scientific A)F		9. PROCUREMENT	INSTRUMENT ID	ENTIFICATION	NUMBER
		AFOSR-86-	0253		
C. ADDRESS (City, State and ZIP Code)		10. SOURCE OF FU	NDING NOS.	<u> </u>	
Bolling Air Force Base, DC 2-	332=7448	PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNI NO.
11. TITLE (Include Security Classification)	atrop Poer	61102F	2917	A3	
-rdo-hmentrici an vanced rie	ccion beam		-	1	
12. PERSONAL AUTHORIS					
12. PERSONAL AUTHOR(S) James Lukens			- <b>4</b>		
Litinggraphy System       12. PERSONAL AUTHOR(S)       James Lukens       13a TYPE OF REPORT       13a TYPE OF REPORT       13b TIME	COVERED	14. DATE OF REPO	RT (Yr , Mo., Dey	/ 15. PAGE	COUNT
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. TYPE OF REPORT         13. Scientific         Final:         Scientific	COVERED 15/86_ TO _7/14/2	14. DATE OF REPO	RT (Yr. Mo., Dey	/ <b>15. PAGE</b> 3	COUNT
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         14. TYPE OF REPORT         15. TYPE OF REPORT         16. TYPE OF REPORT	COVERED 15/86_ TO _7/14/;	14. DATE OF REPO	RT (Yr. Mo., Dey	15. PAGE	COUNT
12. PERSONAL AUTHOR(S)         James Lukens         13a TYPE OF REPORT         13a TYPE OF REPORT         13a TYPE OF REPORT         13b TIME         Final: scientific         FROM7_/         16. SUPPLEMENTARY NOTATION         17.         COSATI CODES	COVERED 15/86_ TO _7/14/2	14. DATE OF REPO	RT (Yr. Mo., Day	15. PAGE 3	COUNT
LILINOGRAPHY SYSTEM       12. PERSONAL AUTHOR(S)       James Lukens       13. TYPE OF REPORT       13. TYPE OF REPORT       Final: scientific       FROM7_/       16. SUPPLEMENTARY NOTATION       17       COSATI CODES       FIELD       GROUP       SUE. GR.	COVERED 15/86_ TO _7/14/3 18 SUBJECT TERMS ( electron 1	Continue on reverse if n	RT (Yr, Mo., Dey lecemary and ident	15. PAGE 3	
12. PERSONAL AUTHOR(S)       James Lukens       13. TYPE OF REPORT       13. TYPE OF REPORT       13. TIME       Final: scientific       FROM74       16. SUPPLEMENTARY NOTATION       17.       COSATI CODES       FIELD       GROUP       SUB. GR.	COVERED 15/86_ TO _7/14/3 18 SUBJECT TERMS ( electron 1	Continue on reverse of n beam lithograp	RT (Yr , Mo., Dey necessary and ident hy	15. PAGE 3	
12. PERSONAL AUTHOR(S)         James Lukens         13a TYPE OF REPORT         13b TIME         Final: scientific         FROM7/1         16. SUPPLEMENTARY NOTATION         17       COSATI CODES         FIELD       GROUP         SUB. GR.         19. ABSTRACT (Continue on reverse if necessary of Equipment has been suited	COVERED 15/86_ TO 7/14/3 18 SUBJECT TERMS ( electron 1 Ind identify by block numb	Continue on reverse of n beam lithograp	RT (Yr. Mo., Dey receivery and ident hy	) 15. PAGE 3 11/y by block numb	
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TIME         Final: scientific         FROM7_/         16. SUPPLEMENTARY NOTATION         17.         COSATI CODES         FIELD         GROUP         SUB. GR.         19. ABSTRACT (Continue on reverse if necessary of Equipment has been purch electron beam lithography (EB)	COVERED 15/86_ TO_7/14/2 18 SUBJECT TERMS ( electron 1 ased under this L) system at Sto	Continue on reverse of mero beam lithograp grant to develop ony Brook for	AT (Yr. Mo., Dey eccentry and ident hy lop and bui the support	15. PAGE 3 Thy by block numb	count er;
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TYPE OF REPORT         13. SCIENTIFIC         FIRAL: SCIENTIFIC         16. SUPPLEMENTARY NOTATION         17.         COSATI CODES         FIELD         GROUP         SUB. GR.         19. ABSTRACT (Continue on reverse if necessary of Equipment has been purch electron beam lithography (EB projects on superconducting electron beam lithography (EB projects on superconducting electron beam lithography (ETM)	COVERED 15/86_ TO _7/14/3 18 SUBJECT TERMS ( electron 1 ased under this blo system at Sto electronics. The	Continue on reverse of merco beam lithograp	AT (Yr, Mo., Dey eccentry and ident hy lop and bui the support sed on an A	15. PAGE 3 Thy by block numb Id a researc of researc mray scanni	count er) cch
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TIME         Final: scientific         FROM7_/         16. SUPPLEMENTARY NOTATION         17         COSATI CODES         FIELD         GROUP         SUE. GR.         19. ABSTRACT (Continue on reverse if necessary of Equipment has been purch electron beam lithography (EB projects on superconducting e electron microscope (SEM) whito to monitor stage position. Hereit	COVERED 15/86_ TO _7/14/2 18 SUBJECT TERMS electron l ased under this bl) system at Sto electronics. The ch has been mod ligh precision no	Continue on reverse of a beam lithograph ar) grant to deve bony Brook for e system is ba ified to accep onmagnetic stat	AT (Yr. Mo. Dey eccentry and ident hy lop and bui the support sed on an A t a laser i ges have be	<pre>/ 15. PAGE 3 /// by block numb ld a resear of researc mray scanni nterferomet en added. a</pre>	count count cch ch .ng .er .nd
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. SUPPLEMENTARY NOTATION         17. COSATI CODES         FIELD       GROUP         SUB. GR.         13. ABSTRACT (Continue on reverse if necessary of Equipment has been purch         electron beam lithography (EB         projects on superconducting e         electron microscope (SEM) whi         to monitor stage position. H         interface electronics have be	COVERED 15/86_ TO _7/14/3 18 SUBJECT TERMS ( electron I ased under this L) system at Sto electronics. The ch has been mod ligh precision no en designed and	Continue on reverse if a beam lithograp grant to deve ony Brook for a system is ba ified to accep onmagnetic stay built to perm	AT (Yr. Mo. Dey eccentry and ident hy lop and bui the support sed on an A t a laser i ges have be it control	15. PAGE 3 17, by block numb 1d a resear of researc mray scanni nterferomet en added, a of the beam	count count cch ch .ng .er .nd
12. PERSONAL AUTHOR(S)         James Lukens         13a TYPE OF REPORT         15. SUPPLEMENTARY NOTATION         17. COSATI CODES         FIELD GROUP         50	COVERED 15/86_ TO _7/14/2 18 SUBJECT TERMS electron l ased under this ased under this close the seen modilised ligh precision not en designed and an external cor-	Continue on reverse if a beam lithograp grant to deve ony Brook for a system is ba ified to accep onmagnetic stay built to perm aputer. The cu ition of 30mm	AT (Yr. Mo. Dey and bui the support sed on an A t a laser i ges have be it control ompleted sy and a posit	15. PAGE 3 17 by block numb of researc mray scanni nterferomet en added, a of the beam stem is des ional accur	count count ch h h ser and h signed cacy
12. PERSONAL AUTHOR(S) James Lukens         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TIME         Final: scientific         FRACT CODES         FIELD         GROUP         SUB. GR.         19. ABSTRACT (Continue on reverse if necessary of Equipment has been purch         electron beam lithography (EB         projects on superconducting e         electron microscope (SEM) whit         to monitor stage position. H         interface electronics have be         position and beam blanking by         to write over a four inch waf         of 100nm.	COVERED 15/86_ TO _7/14/2 18 SUBJECT TERMS ( electron I ased under this based under this based under this based under this based under this clectronics. The ch has been mod ligh precision no en designed and an external con er with a resolu-	Continue on reverse of a beam lithograph grant to develop ony Brook for e system is ba ified to accep onmagnetic stay built to perm aputer. The co stion of 30nm	AT (Yr. Mo. Dey accessory and ident hy lop and bui the support sed on an A t a laser i ges have be it control ompleted sy and a posit	<pre>/ 15. PAGE 3 // 3 // by block numb // characterized in the sear commany scanni nterferomet en added, a of the beam // stem is des ional accur</pre>	count cch ch ch ch cr ind igned acy
12. PERSONAL AUTHOR(S) James Lukens         13. TYPE OF REPORT         13. SCIENTIFIC         14. SUPPLEMENTARY NOTATION         17. COSATI CODES         FIELD       GROUP         SUE. GR.         13. ASSTRACT (Continue on reverse if necessary of Equipment has been purch         electron beam lithography (EB         projects on superconducting e         electron microscope (SEM) whit         to monitor stage position. H         interface electronics have be         position and beam blanking by         to write over a four inch waf         of 100nm.	COVERED 15/86_ TO _7/14/3 18 SUBJECT TERMS ( electron I ased under this L) system at Sta electronics. The ch has been modiligh precision no ten designed and an external con er with a resolu-	Continue on reverse if a beam lithograp grant to deve ony Brook for a system is ba ified to accep onmagnetic stay built to perm aputer. The countries of 30nm	AT (Yr. Mo. Dey decemery and identi- hy lop and bui the support sed on an A t a laser i ges have be it control ompleted sy and a posit	, 15. PAGE 3 Thy by block numb of researc mray scanni nterferomet en added, a of the beam stem is des ional accur	count count cch th ang ter and b signed tacy
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TIME         Final: scientific         FROM7_/         10. SUPPLEMENTARY NOTATION         17.         COSATI CODES         FIELD         GROUP         SUB. GR.         19. ABSTRACT (Continue on reverse if necessary of Equipment has been purch electron beam lithography (EB projects on superconducting e electron microscope (SEM) whi to monitor stage position. H interface electronics have be position and beam blanking by to write over a four inch waf of 100nm.	COVERED 15/86_ TO _7/14/3 18 SUBJECT TERMS ( electron I ased under this L) system at Sto lectronics. The ch has been mod ligh precision no en designed and an external con er with a resolu-	Continue on reverse if a beam lithograp grant to dever ony Brook for a system is ba ified to accep onmagnetic stay built to perm aputer. The co stion of 30nm	AT (Yr. Mo. Dey eccentry and ident hy lop and bui the support sed on an A t a laser i ges have be it control ompleted sy and a posit	, 15. PAGE 3 Thy by block numb of researc mray scanni nterferomet en added, a of the beam stem is des ional accur	count cch ch er and b igned cacy
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. TYPE OF REPORT         13. TIME         Final: scientific         FROM7_/         16. SUPPLEMENTARY NOTATION         17.         COSATI CODES         FIELD         GROUP         SUB. GR.         19. ABSTRACT (Continue on reverse if necessary of Equipment has been purch         electron beam lithography (EB         projects on superconducting e         electron microscope (SEM) whit         to monitor stage position. H         interface electronics have be         position and beam blanking by         to write over a four inch waf         of 100nm.	COVERED 15/86_ TO _7/14/2 18 SUBJECT TERMS ( electron I ased under this ased under this L) system at Sta electronics. The ch has been mod ligh precision no en designed and an external con er with a resolu-	Continue on reverse of a beam lithograph ary grant to develop by Brook for a system is ba ified to accep onmagnetic stay built to perm aputer. The co ution of 30nm	AT (Yr. Mo. Dey accessory and ident hy lop and bui the support sed on an A t a laser i ges have be it control ompleted sy and a posit	<pre>/ 15. PAGE 3 // 3 // by block numb // caresear // 3 // by block numb // caresear // 3 // by block numb // 15. PAGE // 3 // 3 // 15. PAGE // 3 // 15. PAGE // 3 // 15. PAGE // 15. PAG</pre>	count count ch th ang er and b igned acy
2. PERSONAL AUTHOR(S) James Lukens 3. TYPE OF REPORT Final: scientific 7. COSATI CODES FIELD GROUP SUB. GR. 7. COSATI CODES FIELD GROUP SUB. GR. 7. COSATI CODES FIELD GROUP SUB. GR. 7. COSATI CODES FIELD GROUP SUB. GR. 9. ABSTRACT (Continue on reverse (I recessory of Equipment has been purch electron beam lithography (EB projects on superconducting e electron microscope (SEM) whi to monitor stage position. H interface electronics have be position and beam blanking by to write over a four inch waf of 100nm. 0. DISTRIBUTION/AVAILABILITY OF ABSTRIANCE NCLASSIFIED/UNLIMITED & SAME AS RP	COVERED 15/86 18 SUBJECT TERMS ( electron l ased under this ased under this close the seen modi- ligh precision no en designed and an external con- er with a resolu- ACT T C DTIC USERS []	Continue on reverse if a beam lithograp grant to deve ony Brook for a system is ba ified to accep onmagnetic stay built to perm aputer. The cu ution of 30nm of 21 AGSTRACT SEC uncla	AT (Yr. Mo. Dey decemery and ident hy lop and bui the support sed on an A t a laser i ges have be it control ompleted sy and a posit URITY CLASSIFI Splited	, 15. PAGE 3 Thy by block numb of researc mray scanni nterferomet en added, a of the beam stem is des ional accur	count ch ch ch ing er ind isigned acy
12. PERSONAL AUTHOR(S)         James Lukens         13. TYPE OF REPORT         13. TIME         Final: scientific         Final: scientific         13. SUPPLEMENTARY NOTATION         17. COSATI CODES         FIELD         GROUP         SUB. GR.         19. ABSTRACT (Continue on reverse if necessory of Equipment has been purche electron beam lithography (EB projects on superconducting e electron microscope (SEM) whit to monitor stage position. H interface electronics have be position and beam blanking by to write over a four inch waf of 100nm.         20. DISTRIBUTION/AVAILABILITY OF ABSTR UNCLASSIFIED/UNLIMITED & SAME AS RP         22. NAME OF RESPONSIBLE INDIVIDUAL	COVERED 15/86_ TO _7/14/3 Plectron l ased under this clectronics. The ch has been mod ligh precision no en designed and an external con er with a resolution ACT T C OTICUSERS C	Continue on reverse of a beam lithograph ar) grant to dever bony Brook for e system is ba ified to accep built to perm aputer. The co ution of 30nm of 21 ABSTRACT SEC uncla 22b TELEPHONE N	AT (Yr. Mo. Dey accessory and ident hy lop and bui the support sed on an A t a laser i ges have be it control ompleted sy and a posit URITY CLASSIFI Splited	<pre>/ 15. PAGE 3 // 3 // by block numb // caresearc mray scanni nterferomet en added, a of the beam stem is des ional accur // carlon // 22c OFFICE SY// 22C OFFICE SY/// // 22C OFFICE SY// 22C OFFICE SY</pre>	count cch th .ng .er .nd b .igned acy

522222 11 212255153

3

Care V Star Date Star

## AFOSR TR. 88-0

## Final Report

Equipment for an Advanced Electron Beam Lithography System

Equipment has been purchased under this grant to develop and build a research electron beam lithography (EBL) system at Stony Brook for the support of research projects on superconducting electronics. The system is based on an Amray scanning electron microscope (SEM) which has been modified to accept a laser interferometer to monitor stage position. High precision nonmagnetic stages have been added, and interface electronics have been designed and built to permit control of the beam position and beam blanking by an external computer. The completed system is designed to write over a four inch wafer with a resolution of 30nm and a positional accuracy of 100nm.

The SEM selected for this project was an Amray model 1645. The major features which led to the selection of this machine were: The oversized chamber, which is appproximitely 11 in.  $\times$  11 in., is large enough to accommodate stepping motor controlled stages with 4 in. travel. A LaB<sub>6</sub> filament for high beam current was available and was purchased with the instrument. The maximum accelerating voltage is 50KV. This is important when doing ultrahigh resolution (< 100nm) beam writing on standard substrates (e.g., silicon wafers) in order to avoid exposure of the resist by backscattered electrons from the substrate. Finally, an electrostatic beam blanking system with a response time of 0.1µs was provided as part of the instrument.

The major modification made by Amray to this standard SEM was the addition of two ports for a laser interferometer. These ports were positioned so

186 **૱**૱ ૱ **૱** 

that the orthogonal laser beams would intersect the electron beam axis 1 cm below the end cap of the final lens. This 1 cm distance is the planned substrate position during beam writing. A commercial Hewlett Packard laser interferometer system was purchased to monitor the stage position. Differential interferometers were used allowing the interferometer beam splitters and reference mirrors to be placed outside the vacuum system without introducing errors due to the windows and atmosphere. The interferometer has a specified accuracy of 5nm. After allowing for errors due, for example, to the thermal expansion and contraction of the stage, an overall accuracy of better than 100nm in pattern positioning is expected.

The stages purchased for the EBL system were Klinger UT100 stepping motor stages with 4 in. of travel on each axis. These stages were specially modified to remove all magnetic material, since any change in the magnetic field on the electron beam due to stage motion would cause an unknown shift in the beam position and a resulting loss of positional accuracy. The stages arc positioned using Aerotech stepping motors and computer interfaceable. programmable controller. The stepping motors are located outside of the vacuum chamber.

Fine positioning of the electron beam in a  $100\mu m \times 100\mu m$  field on the substrate is done by computer controlled beam deflection. To stitch these  $100\mu m$  fields together in order to write over a larger area, the stage is moved a programmed amount under computer control. The accuracy of the stage itself. about  $\pm 1\mu m$ , is far less than required, thus an error signal is generated by the laser interferometer to be fed back into the computer beam deflection program in

order to achieve the desired  $0.1\mu m$  stitching accuracy.

A Hewlett Packard series 300 computer is used to generate the 16-bit addresses for the beam position. An interface between the computer and the SEM has been built; this converts the digital addresses to analog voltages for beam deflection. In addition, the interface controls the system timing: The beam is moved to the programmed position, allowed to settle for a preprogrammed time, unblanked for a second preprogrammed interval, reblanked and then moved to the next position. The interface also can generate separate outputs to the beam scan coils and to the viewing CRT. This permits accurate registration of two sequential layers.

A climate controlled clean room has been built, using University matching funds for this grant, to house this new EBL system.

Accesion For	
NTIS CRA&I DTIC TAB Upamous tof Usef Deal Store	
By Destroy Solo /	
Dist Spor	nd For Stal
A-1	



END DATE FILMED DTIC July 88