U.S. DEPARTMENT OF ENERGY

FIELD WORK PROPOSAL

1. WORK PROPOSAL NO.: JLAB-HEP-XX	2. REVISION NO.: 1	3. DATE PREPARED: 2/06
4. WORK PROPOSAL TITLE: Preparation and Testing of Multilayer SRF Films	5. BUDGET AND REPORTING CODE:	
6. WORK PROPOSAL TERM: 10/1/2006 to 9/30/2007		
7. HEADQUARTERS OFFICE PROGRAM MANAGER: Robin Staffin, Assoc. Dir., HEP (301) 903-3624 hep-tech@science.doe.gov	8. HEADQUARTERS ORGANIZATION: Office of High Energy Physics, SC-20	
9. DOE FIELD ELEMENT WORK PROPOSAL REVIEWER: Jim Turi, (757) 269-7146, turi@jlab.org	10. DOE FIELD ELEMENT: Oak Ridge Operations	
11. CONTRACT WORK PROPOSAL MANAGER: Swapan Chattopadhyay, (757) 269-7001 swapan@jlab.org	12. CONTRACTOR NAME: Southeastern Universities Research Association, Inc., Thomas Jefferson National Accelerator Facility (Jefferson Lab)	

13. Work Proposal Description

Principal Investigators: Larry Phillips

Recent theoretical work by Alex Gurevich at U. Wisconsin and others raises the prospect of a new class of high performance SRF materials for use in particle accelerator applications. The use of thin, multi-layer superconductor/insulator structures may significantly raise the theoretical maximum field sustainable by the surface. This work will apply existing infrastructure at JLab to prepare a series of model surfaces and characterize their performance (magnetic flux penetration and rf surface impedance). By evaluating the small-sample performance of such structures, one may obtain early demonstration of the basic desired phenomenon and thus build a foundation for exploration of preparation of the more complex geometries required of accelerator applications. The long-term benefit may be the realization of higher accelerating gradients at warmer temeratures, e.g. 100 MV/m @ 4.2 K, with reduced unit fabrication costs.

14. CONTRACTOR WORK PROPOSAL MANAGER	15. OPERATIONS OFFICE REVIEW OFFICIAL
Signature ____________ Date	Signature ____________ Date

16. DETAIL ATTACHMENTS

______	a. Facility Requirements	______	f. Technical Progress	______	k. Deliverables
______	b. Publications	______	g. Future Accomplishments	______	l. Performance measures/expectations
x	c. Purpose	x	h. Relationships to Other Projects	______	m. ES&H Considerations
x	d. Background	______	i. NEPA Projects	______	n. Human/Animal Subjects
x	e. Approach	______	j. Milestones	______	o. Other (Specify)

WORK PACKAGE REQUIREMENTS FOR OPERATING/EQUIPMENT
OBLIGATIONS AND COSTS

CONTRACTOR NAME:	WORK PROPOSAL #:	REV. #:	DATE PREPARED:
Southeastern Universities Research Association, Inc. Thomas Jefferson National Accelerator Facility (Jefferson Lab)	JLAB-HEP-XX	1	2/06

	FY 2006 Allocated	FY 2007 Target	FY2008 Target	FY 2007 Requirements	FY 2007 Authorized
17. STAFFING (IN STAFF YEARS)					
a. SCIENTIFIC		0.9			
b. OTHER DIRECT		1.1			
c. TOTAL DIRECT		2.0			
18. OPERATING EXPENSE (in thousands)					
a. TOTAL OBLIGATIONS (B/A)		350			
b. TOTAL COSTS (B/O)		350			
19. EQUIPMENT (in thousands)					
a. EQUIP OBLIGATIONS (B/A)					
b. EQUIPMENT COSTS (B/O)					

20. MILESTONE SCHEDULE (Tasks)	Dates	Proposed $	Authorized $
Prepare and compare ECR plasma deposited Nb film with Nb/Insulator/Nb film --	12/06	$110k	
Prepare and characterize sputtered Nb/Insulator/Nb film	3/07	$90k	
Prepare and characterize ECR plasma deposited high-kappa film/Insulator/Nb film	6/07	$150k	

21. REPORTING REQUIREMENTS (Description):

TITLE:	BUDGET AND REPORTING CODE	DATE PREPARED
ILC CRYOMODULE VALUE ENGINEERING		7/05
WP NUMBER	CONTRACTOR NAME:	
JLAB-HEP-XX	Southeastern Universities Research Association, Inc., Thomas Jefferson National Accelerator Facility (Jefferson Lab)	

16. c. Purpose

The recent suggestion by Alex Gurevich of using thin multilayer films to avoid the rf losses due to fluxoid entry—present with high K films—opens up a completely new opportunity for thin film cavity structures and thus low cost linac production. The rf surface impedance of such materials has never been measured. This work undertakes to produce such films on small samples and characterize their rf behavior.

16. d Background

The potential for linac cost reduction using thin film cavities has not been aggressively explored, primarily due to the severe Q slope seen with sputtered niobium films. Early sputtered films were highly columnar and voided as is the case with any refractory metal deposited at low temperatures. It was often suggested that this contributes to the anomalous losses and a number of weak link models were generated to explain this behavior. Through heroic efforts by the CERN group, their deposition process was developed to the degree that very dense, high quality films were produced. There still remained some degree of Q slope, sufficient to make the process unattractive in high field applications.

It has long been assumed that thin film cavities provide only two avenues for cost reduction, less niobium is used and no magnetic shielding is required to achieve good Q values. For the LEP project at CERN the cost of producing a cryomodule using thin film technology was about the same as bulk niobium structures. This produced the lasting impression that the potential for cost reduction is insignificant. The reason for this was that due to the thin film process development required and the limited project size and schedule, it was not feasible to do more at that time than deposit niobium films on copper sheets which was formed and electron beam welded in the same manner as bulk niobium cavities in a relatively conventional cryostat.

The Nb films produced by magnetron sputtering have also exhibited very high values of Hc2 which implies a low value of Hc1. Hc1 is difficult to measure and to our knowledge the surface value relevant to the RF field has never been measured. A niobium film with a depressed Hc1 would show an early onset of Q drop which would be further aggravated by surface roughness. Some early CERN measurements suggest a correlation of Q slope with copper substrate roughness. Low values of Hc1 and the correspondingly poor high field performance are the reason that many otherwise potentially attractive alternatives to niobium have not been pursued.

16. e. Approach

To establish the credibility of this approach one must

- Demonstrate the suppression of vortex entry on small flat multilayer samples without RF.
- Measure the effect of such suppression on the high field RF surface impedance at 2 K.
- Repeat with a high-K film using the same process.

Intended work sequence:
Task 1:
Measure the flux penetration of a well characterized niobium film produced by the JLAB ECR vacuum plasma deposition system as a function of magnetic field strength applied parallel to the surface. Film edges are shielded from all field components.

Task 2:
Repeat Task 1 using a two layer niobium film separated by a 1 nm insulating layer for several films of thickness less than one SC penetration depth as required by the Gurevich model. Compare the flux penetration vs. field curve with the single film of Task 1.

Task 3:
Measure the RF surface impedance as a function of field and temperature in a TE011 cavity for film structures described in 2.

Task 4:
Repeat Task 2 using standard magnetron sputtering instead of the ECR plasma. This will give an indication of how the CERN films would perform if the Gurevich model were applied to an existing process technology with well characterized cavity performance.

Task 5:
Measure the RF surface impedance as a function of field and temperature in a TE011 cavity for film structures described in 4.

Task 6:
Repeat Task 2 using one high K film over an insulator and niobium film. Compare the flux penetration vs. field curve with those of 2 and 4.

Task 7:
Measure the RF surface impedance as a function of field and temperature in a TE011 cavity for film structures described in 6.

16. h. <u>Relationships to Other Projects</u>

This work is in collaboration with Alex Gurevich and others and is complementary to the university proposal from the Wisconsin group.