BUD-11A (1-07)
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U. S. DEPARTMENT OF ENERGY
FIELD WORK PROPOSAL

1. WORK PROPOSAL NO.:	2. REVISION NO.:	3. DATE PREPARED:	3a. CONTRACTOR NO.:
2703.2		03-15-07	53211

4. WORK PROPOSAL TITLE:
SCRF Material D&D

5. BUDGET & REPORTING CODE:	6. WORK PROPOSAL TERM:	7. IS THIS WORK PACKAGE INCLUDED IN THE INST. PLAN?	7a. PRINCIPAL INVESTIGATORS:
KA-15-01	Begin: End:	☒ YES ☐ NO	Norem, J.

8. HEADQUARTERS/OPERATIONS OFC PROGRAM MANAGER: Staffin, R. No. 301-903-3624	11. HEADQUARTERS ORGANIZATION: High Energy Physics	14. DOE ORG. CODE: SC
9. DOE FIELD ORGANIZATION WORK PROPOSAL REVIEWER:	12. DOE FIELD ORGANIZATION: Chicago	15. DOE ORG. CODE: CH
10. CONTRACTOR WORK PROPOSAL MANAGER: Weerts, H.J. No. 630-252-8831	13. CONTRACTOR NAME: UChicago Argonne, LLC	16. CODE: 12

17. IS THIS PROPOSAL TO DO WORK THAT INCLUDES A SECURITY INTEREST? ☐ YES ☒ NO

18. WORK PROPOSAL DESCRIPTION (Approach, anticipated benefit in 200 words or less):

The superconducting rf technology developed over the last 20 years is not able to routinely reach the maximum achievable accelerating gradients for a variety of reasons. Using atomic layer deposition, it seems possible to manufacture thin composite materials that are, in principle, able to avoid all the failure mechanisms of existing accelerating structures. We are starting an effort aimed at developing this technology to the point where it could be used to construct the rf structures used in the International Linear Collider and other linacs.

19. CONTRACTOR WORK PROPOSAL MANAGER:		20. OPERATIONS OFFICE REVIEW OFFICIAL:	
H. Weerts	03-15-07		03-15-07
SIGNATURE	DATE	SIGNATURE	DATE

21. DETAIL ATTACHMENTS: (See specific attachments.)

☐ a. Facility requirements	☒ e. Approach	☐ i. NEPA requirements	☐ m. ES&H considerations
☐ b. Publications	☒ f. Technical progress	☒ j. Milestones	☐ n. Human/Animal Subjects
☒ c. Purpose (mandatory)	☒ g. Future accomplishments	☐ k. Deliverables	☐ o. Security requirements
☐ d. Background	☒ h. Relationships to other projects	☐ l. Performance Measures/Expectations	☒ p. Other (specify)

WORK PROPOSAL REQUIREMENTS FOR OPERATING/EQUIPMENT OBLIGATIONS AND COST

CONTRACTOR NAME	WORK PROPOSAL NO.	REVISION NO.	CONTRACTOR NO.	DATE PREPARED
UChicago Argonne, LLC	2703.2		53211	02/09/2007

	PRIOR YEARS	FY2007	FY2008 ESTIMATE	FY2009 REQUEST	FY2009 AUTHORIZED	FY2010	FY2011	TOTAL TO COMPLETE
21. STAFFING (in staff years)								
a. Scientific		0.0	3.0	4.0		0.0	0.0	
b. Other Direct		0.0	1.0	1.0		0.0	0.0	
c. Technical Services*		0.0	0.0	0.0		0.0	0.0	
d. Total Direct		0.0	4.0	5.0		0.0	0.0	
23. OBLIGATIONS AND COSTS (in thousands)								
a. Total Obligations		0	824	919		0	0	
b. Total Costs		0	781	911		0	0	
24. EQUIPMENT (in thousands)								
a. Equipment Obligations		0	0	0		0	0	
b. Equipment Costs		0	0	0		0	0	

25. MILESTONE SCHEDULE (Tasks)	FY2009 DOLLARS PROPOSED	FY2009 DOLLARS AUTHORIZED	PROPOSED SCHEDULE	AUTHORIZED SCHEDULE

26. REPORTING REQUIREMENTS

* Technical services staffing includes ANL support divisions' scientific effort.

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CONTRACTOR NAME	CONTRACTOR CODE	CONTRACTOR NUMBER	
UChicago Argonne, LLC	CH	53211	
WORK PACKAGE NUMBER	WORK PROPOSAL NUMBER	DATE PREPARED	REVISION NUMBER
	2703.2	03-15-07	

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- ☐ a. Facility requirements
- ☐ b. Publications
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- ☐ d. Background
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- ☐ p. Other (specify)

Development of Nano-Fabricated Composites for Superconducting RF

Recent progress with ILC structure development has shown that the standard method of producing rf cavities (forming, baking, cleaning, etc.) does not reliably produce the gradients required by the ILC design. (Current averages are 25 +- 4 MV/m produced, and >35 required). The failure modes of these structure are becoming better known, in part because of work in the Neutrino Factory / Muon Collider.

M. Pellin, ANL/MSD, has proposed the use of Atomic Layer Deposition (ALD) to produce surfaces that could be better and cheaper than producing superconductors the standard way. Structures fail due to: 1) field emission, 2) critical field limits, 3) high field Q slope, and 4) multipacting. It seems possible to fabricate inexpensively structures which: 1) coat the substrate with thick Nb layers that increase local radii, decreasing local fields below field emission thresholds, 2) are layered, so critical fields are filtered (A. Gurevich), 3) are pure enough so that models of high field Q slope are invalid, and, 4) can be covered with monolayers of TiN to quench multipacting. It is important to emphasize that this technology seems to be able to remove all known constraints on SCRF gradients and also significantly reduce the cost of these structures.

Although the technology of ALD is fairly well advanced, the requirements of high gradient accelerators are unexplored. It will be necessary to learn how to deposit pure Nb, Al2O3, MgB2, TiN, NbN and other materials in acceptable surfaces and test these surfaces. The present plan is the following:

- Phase I, Understand the required chemistry: This will involve primarily surface science technology, with measurements using ellipsometry, Atom Probe Tomography, SIMS, and other techniques (all of which are presently available at Argonne, Northwestern, and the University of Chicago). In addition a small theoretical effort (perhaps within A. Abrikosov’s group at Argonne) would be very helpful. This effort must be accompanied with an active SRF materials program aimed at understanding superconducting surfaces.
- Phase II, Test coatings in cavities: This work will require the construction of a larger deposition chamber, the use of a variety of cavities (1 and 9 cell), and test equipment, including cryogenics and supplies for high power testing.

a) FY 2007 Accomplishments: We have begun preliminary experiments aimed at growing niobium and Al2O3. These tests will be measured with existing instrumentation at ANL and Northwestern.

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b) <u>FY2008 Plans</u>: In order to fully exploit this method it will be necessary to demonstrate the capability to deposit layered composites, (perhaps MgB_2 on Al_2O_3 on Nb on Cu) using technology appropriate to cavities. We will construct a deposition chamber for larger cavities.

c) <u>FY2009/10 Plans</u>: The program will do iterative studies looking at how the properties of the deposited surfaces determine the high gradient cavity performance, coordinating this work with the ILC program.