**DOE/PC/95231-10
DIST. CATEGORY UC-112
UTSI-97-01**

**TECHNICAL PROGRESS REPORT
FOR
UTSI/CFFF MHD PROGRAM COMPLETION
AND RELATED ACTIVITY**

**For The Period
January 1, 1997 - March 31, 1997**

April 1997

Work Performed Under Contract No. DE-AC22-95PC95231

**Prepared for:
The United States Department of Energy**

**Prepared by:
The University of Tennessee
Space Institute
Energy Conversion Research and Development Programs**

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EXECUTIVE SUMMARY

Routine preventive maintenance of the DOE Coal Fired Flow Facility (CFFF) is being performed. Modernization programs, being funded under subcontract from Foster Wheeler Development Corporation by the DOE HIPPS Program, are being implemented on the coal processing system, the data acquisition and control system and the control room.

Environmental restoration actions continued with monitoring of groundwater wells and holding pond effluent. Actions are underway to dispose of spent seed/ash mixtures and excess coal remaining from the MHD POC program.

One additional research subtask in the High Temperature Superconductor (HTS) Program was approved and funded by DOE this quarter. Initial work began on this project. Work continued on the other five projects.

TASK 1 - FACILITY AND PROPERTY MANAGEMENT

Activities this quarter were concentrated on the facility preventive maintenance /repairs required to maintain the Coal Fired Flow Facility in a standby condition. Weekly and monthly equipment maintenance procedures were performed for facility air compressor systems, cooling water pumps, coal processing system motors, steam boiler systems, ID and FD fans, and fire water system equipment.

A lab analysis of the remaining CFFF raw and spent seed has been received and planning is continuing for disposal of this waste. Extensive repairs to the coal weigh feeder were completed this month. The coal feeder belt was replaced and several coal weigh calibration system components were repaired or replaced. Removal of service lines and equipment on the primary furnace was started this quarter in order to prepare for the installation of the HIPPS HITAF. Installation of the high pressure steam system continued. A boiler feedwater preheat tank was located and modified. An inspection of the boiler feedwater pump revealed damage and replacement bearings, gaskets, and a gear assembly were installed on the pump. The boiler was placed in its permanent location (the rotary drum filter shelter) and the boiler exhaust stack was installed.

The first phase APACS control system, computers and software were delivered in early January. Training and familiarization on the APACS 4-Mation software started this quarter with two training sessions being conducted by the vendor. Upgrade of the CFFF control room is nearly completed. The sprinkler system, air conditioner ductwork, suspended ceiling, and control system consoles were installed this quarter.

Upgrade of the gas analysis system also started this quarter. Vacuum pumps for the NO_x analyzers were serviced and three existing SO₂ gas analyzers are being converted to CO and CO₂ analyzers.

TASK 2 - REPORTING AND ARCHIVING

The October - December 1996 Quarterly Technical Progress Report was approved on March 26, 1997.

The October - December 1996 Key Staffing Report was completed and mailed on January 15, 1997.

The Semi-Annual Government Property Report and Consolidated Equipment Listing was completed for the period September 1, 1996 - February 28, 1997 and mailed March 11, 1997.

All major pieces of equipment, mechanical and utility systems, and test hardware items in the CFFF have been documented with drawings and specifications. All hardware and systems added to the CFFF or modified since 1985 have been documented in AutoCAD format. Original drawings, microfilm copies and computer disks are maintained for archival purposes as well as daily use in maintaining the CFFF. The Design Engineering Department continues to support the collection, filing and updating of CFFF mechanical system design documentation.

TASK 3 - SITE ENVIRONMENTAL COMPLIANCE AND REMEDIATION

Approval to dispose of the remaining 17 tote bins and ash is still in progress. UTSI is working with TRW property manager Vince Zorzoli in California on this matter.

Approval from the State of Tennessee to dispose of remaining coal ash and potassium carbonate has not arrived. UTSI will contact the State of Tennessee on the status of this approval. The fees and forms have been sent to the appropriate State water quality offices.

Action to cancel Ground Engineering and Testing Service (GETS) as the UTSI groundwater consultant is underway. The company has defaulted on their agreement to furnish a report. After formal notification UTSI will recommend that the company be put on the University-Wide ineligible bidders list.

The State of Tennessee has verbally expressed that it would like for UTSI to "close the loop" on this particular aspect of the groundwater investigation. The State is wanting a summary report, and will send a letter requesting a report.

A condensed report will be filed by UTSI representatives from the soil and water analysis received from the sample efforts in 1996.

Water sampling, analysis, and reporting were completed on schedule. No out of limit water parameters or "notice of violation" were issued.

TASK 4 - SITE REACTIVATION

No work was scheduled or performed.

TASK 5 - DISASSEMBLY AND DISMANTLEMENT (D&D) OF THE CFFF

No work was scheduled or performed.

TASK 6 - ADVANCED TECHNOLOGY, RESEARCH, DEVELOPMENT AND ENGINEERING FOR OTHER FEDERAL OR DOE PROGRAMS

Subtask 6.02 Evaluation of Methods for Application of Epitaxial Layers of Superconductor and Buffer Layers

During the reporting period, the following progress was made on the above project.

- Multi-attribute analysis was applied to the following parameters for which the quantitative values are available in the literature:
 - J_c
 - toxicity
 - process severity
 - thermal expansion coefficient
 - deposition rate and overall thickness
 - lattice constants

For other important parameters, for which the quantitative values are not available at this time, we plan to provide a subjective/qualitative evaluation.

- For subsequent use in cost estimation, a list of manufacturing parameters has also been put together. In this list, the various parameters have been determined for the options of solgel, MOCVD, PLD, MOD, CVD and Aerosol/spray pyrolysis. Because either adequate data on electrodeposition and electrophoresis are not available or their reported performance is poor, these two options are not included in this list. As mentioned in our earlier quarterly report, the manufacturing parameters are based on the wire production capacity of 6000 km/year as used by Bob Hammond in his work at Stanford University.
- An outline for the preliminary evaluation report has also been prepared and the team members are now putting together the sections related to their responsibilities and work scope.

Subtask 6.03 Coated Conductor Development Steering Committee and Program Management

The major activity under this work element continues to be the development of a Roadmap for Coated Conductor Development. Several working sessions were held with DOE/FETC personnel and their consultants. Also, frequent discussions were held

with members of the Advisory Committee and others by telephone and e-mail. A new draft was prepared and forwarded to Advisory Committee members.

A meeting of the Advisory Committee was held on February 5, 1997, just prior to the Wire Workshop that was held February 6 and 7, 1997.

Subtask 6.04 Optimum Coated Conductor

Multi-Layer Modeling

During this reporting period several modifications were made to the finite element (FE) stress analysis model. In addition, materials characterization has given very good Scanning Electron Microscope (SEM) views of deposited buffer layers on textured nickel substrates. Current work includes focused efforts on isothermal strain loadings (77K) of single CeO_2 layers deposited on nickel RABiTS substrates. SEM and Atomic Force Microscopy (AFM) together with a simple FE model are being used to investigate the influence of working temperatures on layer stresses and possible crack formation.

An overview of model and characterization objectives and status are given at the Wire Development Workshop in Panama City Beach on February 6. Recent micrographs of deposited layers were shown, including those revealing character of thermal etching and minor defects. It is clear that features in the substrate are also evident in deposited layers. The level of detail necessary for characterizing cracks due to thermal stresses is well below that demonstrated in obtaining these pictures. The quality of the presented micrographs indicate that SEM and AFM microscopy will provide adequate information for determining the influence of thermal cycling on crack formation for different thicknesses of a single CeO_2 buffer layer.

The FE model has been modified to use CeO_2 property values provided by ORNL. Although the substrate model remains elastic, this has little bearing on the objectives of characterizing the differences in buffer layer stresses based on layer thickness. A nonlinear model will be implemented when substrate stresses are needed. For this simple problem a 20x30 element two dimensional model has been used to provide stress calculations. Results to date have focused on large layers and show that buffer layer stresses are weakly dependent on buffer layer thickness, and in the thickness range of 100-500 nm, are primarily a function of temperature difference. Smaller layers (~ 1 nm) will be investigated to compare with experimental characterization.

AC Losses

Analytical characterization of the current and field distributions in circular and thin film planar geometries are being investigated. The thin film results have been taken from the open literature and to date only self fields accompanying dc transport current have been considered. For high current carrying capacity the thin film coated conductors can be helically wound to approximate a hollow circular conductor. In such an instance, coupling between the individual conductors becomes important and the division of transport current between layers of the conductor may be nonuniform. To the present only self field of single conductors have been considered. However, in coupled conductors, the self field of a conductor or tape acts as an applied field to its neighbors. During the next quarter, the influence of steady applied fields to the same conductor geometries will be considered with eventual extension to ac transport currents.

Subtask 6.05 Cost Performance Analyses of Potential Manufacturing Processes

Activity under this work element was devoted primarily to gathering data about the performance and cost of potential manufacturing processes and cost of consumable materials.

In the area of the performance of processes, especially maximum deposition rate that can be used and still get good epitaxial deposits, there is still large uncertainty. Consequently, deposition rate will be treated as a parameter and costs explored for a wide range of values.

Current suppliers of YBCO, Y, B, Cu and their precursors used in some processes were queried about current small quantity lot prices and their expectation for prices in large quantities.

Capital equipment cost estimates being developed under Subtask 6.02 will be used for these cost analyses.

Next quarter, initial cost calculations will be completed for PLD and electron beam deposition on RABiTS substrate.

Subtask 6.06 Development of Real Time Process Control Using In-Situ Diagnostics

During the last quarter effort has been expended in determining required process control measurements needed for the various HTSC coated conductor manufacturing techniques and identifying and investigating potential technologies capable of making the needed measurements. In the first area of understanding

process control needs , analyses of each of the different manufacture processes was carried out to determine the types, ranges, accuracies, etc. of required process control measurements. Activities in the second area concentrated on finding methods useful for characterizing the quality of the various layers of coated conductors.

Process Control Tables

To determine the measurements needed in each process, the process diagrams developed under Subtask 6.02 were studied (1). Literature surveys were also done to develop a thorough understanding of each process and a comprehensive tabulation of control parameters (2-4). After the process review, a preliminary worksheet for each process was created that would give a general description of the kinds of measurements needed as well as noting the parameter ranges when available from the literature. Each of the worksheets were studied and reviewed to identify omissions and errors and necessary changes made. After a satisfactory worksheet for each process was completed the information was placed in the form of a table.

The table for each process has seven columns denoted item, measurement, range, accuracy, technology, cost, and comments. The item column identifies the components or subprocesses, such as dissolver or e-beam based YSZ application (see Table 1. MOCVD Method). The measurement column describes what specific measurements will be needed for that item, such as temperature or pressure. The range and accuracy columns give the range of the measurement as well as accuracy specification. The information in the measurement, range, and accuracy columns suggests a measurement technique which is presented in the technology column. Costs for the measurements are given in the cost column. The comments column provides questions or comments pertinent to that item.

At the current time these tables provide only some of the necessary information due to the ongoing development of the manufacturing processes and the unavailability of process details in the open literature. Once completed, the tables will provide valuable information in the further development of the methods by describing processing parameters that must be considered and controlled for the various manufacturing methods.

Table 1. MOCVD Method is given as an example of the process tables. The first item identified in the table is the substrate. Since a high quality superconductor requires a high quality substrate, it is expected that the substrate quality will require monitoring. The measurements prescribed, such as crystal orientation and morphology, would be needed to properly characterize the substrate quality.

Another item listed in the MOCVD Table is the heated piping containing the organic precursor solutions of yttrium, barium, and copper, which must be heated to

Table 1. MOCVD Method

Item	Measurement	Range	Accuracy	Technology	Cost	Comments
Substrate	crystal orientation					
	morphology					
	geometry					
	grain size					
Annealing Furnace	temperature	900 C				
Pipes containing Y, Ba, Cu - TMHD (1)	temperature	Y - 130 C Cu - 130C Ba - 260C				The pipes containing the Y, Ba, Cu-TMHD must be temperature controlled with heat pipes to temperature at least equal to highest evaporation temperature so the chemicals don't condense back.
Dissolver	flow rates of chemicals					Is this a batch or continuous process?
	level					
	temperature					
Vaporizer	temperature	230 C				
	flow rates of chemicals					
E-Beam Based CeO ₂ Application	tape temperature					What are the off-gasses?
	flow rate of off-gasses					
	flow rate of H ₂ /N ₂ mix					
	pressure					
	deposition rate	.0667 nm/s				
CeO ₂ Block	thickness					When does the block need to be replaced? Is the block assumed to be purchased?
	quality					
Film - after CeO ₂ application	layer thickness	10 nm				
	crystal orientation					
	composition					
	morphology					
	geometry					
	grain size					
Electron Gun	power					
	location on target					
E-Beam Based YSZ Application	tape temperature					
	pressure					
	deposition rate	.1167 nm/s				
YSZ Block	thickness					When does the block need to be replaced? Is the block assumed to be purchased?
	quality					
Film - after YSZ application	layer thickness	140 nm				
	crystal orientation					
	composition					
	morphology					
	geometry					
	grain size					
MOCVD - Based HTSC Application	temperature	600-850 C				What are the vapors?
	pressure	1-10mm Hg				
	deposition rate	2 nm/s				
	film temperature	600-850 C				
	transport line temperature					
	flow rate of vapors					

Plasma Tube	flow rate of chemicals					
Film - after HTSC application	layer thickness	300 nm				
	crystal orientation					
	composition					
	morphology					
	geometry					
	grain size					
Oxidation/Annealing	temperature	400-680 C		temperature controller		What are the off-gasses?
	time			temperature controller		
	pressure of O ₂	100 mm Hg				
	flow rate of off-gasses					
Cooling	temperature	680-25 C		temperature controller		What are the off-gasses?
	time			temperature controller		
	pressure of O ₂	100 mm Hg				
	flow rate of off-gasses					
Post Manufacturing Test	quenching and I/V characteristics					
Wire Marking System	wire defects					
Global Measurements	speed of ribbon					The speed of the ribbon should control the processing time.
	tension					
	length of ribbon onto spool					
	CEM (Continuous Emissions Monitoring)					

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appropriate temperatures to ensure evaporation and prevent condensation. The different layer applications, such as the e-beam based YSZ and CeO₂ applications and the MOCVD-based HTSC application, also appear in the items column. Pressure, temperature, and deposition rates are some measurements that must be monitored during these applications. The table also identifies process points where measurements of thickness, crystal orientation, and composition of new film layers are required to control layer deposition and ensure quality. The final oxidation/annealing and cooling steps are shown in the table as a subprocess requiring monitoring and control of temperature, time, and oxygen pressure.

At the end of the table, two items are included which are not part of the process designs at present. These items are post manufacture testing and a wire marking system. The post manufacture testing would provide quality control via a thermal quench of the product and measurement of electrical characteristics. The wire marking system is included to mark any defect

locations detected during manufacture for the purposes of post manufacture processing to remove defective regions. Post manufacture testing and the wire marking system have been included in all of the process control tables.

Layer Quality Assessment

The second area is related to the characterization and quality assessments of the substrate and conductor layers. Two technologies are actively being investigated for this purpose: scatterometry and Raman spectroscopy. Study of scatterometry was undertaken due to its potential for surface roughness measurement while Raman spectroscopy is being studied as a means of measuring crystal composition and orientation.

Surface Roughness

High quality epitaxial growth of superconducting layers on substrates prepared by processes such as RABiTs require smooth substrates suggesting the need for quantifying surface roughness. Atomic force microscopy measurements of RABiT substrates have shown rms surface roughnesses of 50 nm (5) approaching the smoothness of optical quality surfaces (normally less than 10 nm). While such a surface would be considered a good reflector exhibiting primarily specular reflection, it would also show significant diffuse scatter. During the last quarter, research was conducted to assess the potential of determining surface roughness from scattering measurements.

Measurement of the radiation scattered from a surface can be used to determine many surface roughness parameters such as arithmetic average roughness (R_a), rms roughness (R_{rms}), average and rms slope parameters (m_a and m_r), and surface wavelength ($\lambda = 2\pi / m$). These parameters can be obtained from the surface power spectral density (PSD) which describes the surface height variations in terms of surface spatial frequencies. The measurable bidirectional scatter distribution function (BSDF) or specifically for a reflective surface the bidirectional reflection distribution function (BRDF) is related to the surface PSD. Thus measurement of the BSDF allows calculation of surface roughness statistics.

The BSDF is the ratio of scattered power (specifically radiance) to illuminating power (or irradiance). It is bidirectional since both the incident and scatter direction are pertinent. The BRDF is also generally two dimensional (i.e. light is scattered into all directions of the hemisphere above the reflecting surface) since the surface itself is two dimensional though the BRDF for an isotropic surface will not depend on the azimuthal angle.

BRDF measurement is straightforward and is accomplished with scatterometers which are composed of illumination sources (frequently lasers), sample holders, goniometers, and detector electronics. Scatterometers are rugged and provide a rapid non-contact measurement with sub-angstrom accuracies and thus are excellent candidates for characterizing the surface roughness for process control of not only the substrate but other layers of the coated superconductor.

Crystal Composition and Orientation

During the growth of the various layers composing a coated conductor, composition and crystalline orientation must be stringently maintained to ensure an acceptable conductor. Raman spectroscopy can give this information directly and accurately by measuring vibrational modes in the crystal (7, 11, 12). A Raman spectroscopy experimental setup is shown in Figure 1.

In studying the composition of the HTSC, oxygen content must be determined. The critical temperature of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ films is dependent upon the oxygen content, which can be monitored with Raman spectroscopy. By observing the 500 cm^{-1} line in the proper polarization the oxygen content can be found (6, 8, 9, 10).

Also, crystal orientation can be measured by observing several Raman spectra of the HTSC film. By applying different polarizations to the laser, using different orientations of the crystal axes, and studying different places on the film an accurate measurement can be made of the crystal orientation (13-16). For example, by comparing the relative intensities of the 500 cm^{-1} line and the 335 cm^{-1} line in the proper Raman mode the degree of c-axis tilting away from the normal can be determined (15).

The main difficulty with Raman spectroscopy is the speed of data acquisition. To be useful for process control, Raman spectroscopy must provide real time measurements to be used in a processing environment. Real time measurements should be possible under the appropriate conditions (7, 13).

Figure 1. Raman Spectroscopy Setup

Future Work

Work will continue on completion and refinement of the process tables. The process methods must be researched further to provide all necessary information vital to completing the charts.

A scatterometer setup is being developed for measuring BSDF's of coated conductor samples and assessing the abilities of scatterometry for process control. A Raman spectroscopy capability is also being developed to conduct experiments on the utilization of Raman spectroscopy as a tool for studying HTSC films. The Raman spectroscopy system design will be completed shortly and components ordered.

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Subtask 6.07 Innovative Manufacturing Process for Coated Conductors

This is a new work element that was authorized this quarter. The objective is to explore new methods of applying epitaxial layers of buffer layers and possibly superconductors. Initial work concentrated on exploratory techniques to apply candidate materials on inconel substrates using a CO_2 laser. Later in the quarter, the effort switched to nickel as a substrate.

During these efforts, commercially available pure nickel (99.9999%) was used as substrate to deposit the buffer layer. The nickel substrate was 25 mm x 25 mm x 3 mm coupon. Attempts were made to deposit buffer layers of MgO and YSZ on pure nickel substrate using laser techniques. Prior to laser treatment, the nickel substrate was cleaned with alcohol followed by spray deposition of commercially available submicron MgO (350 nm) and YSZ (800 nm) powders. The powders were individually suspended in methyl alcohol as carrier and sprayed with an air-gun to obtain uniform layer of the deposits of different thicknesses. After the deposits were thoroughly dried, thicknesses measured during scratch method are as mentioned in Table 2.

Table 2. Thickness of Pre-coated Powder (Microns)

Sample #	1-4	5	6	7	8	9	10	11	12
MgO	6	39	38	41	40	----	----	----	----
YSZ	----	----	----	----	----	42	24	27	20

As the initial attempts were directed towards evaluation of feasibility of the laser treatment to deposit various types of buffer layers on pure nickel substrate, powders were coated prior to the laser treatment using air-spray gun technique. However, it is proposed that eventually, the powder will be introduced at the laser-substrate interaction region.

The pre-coated nickel substrate was mounted on water cooled copper block to provide cooling in addition to self-cooling during the laser treatment. Such cooling arrangement minimizes and/or eliminates excessive heating of the substrate and thereby associated undesirable metallurgical changes.

The present experimental approach involved laser scanning of the pre-coated surface using a Rofin Sinar RS3000 laser. The RS3000 is a commercially available fast axial flow RF (27.12 Mhz) excited CO₂ (10.6 μ m wavelength) laser. The laser is normally operated in a square wave (approximately), variable duty cycle pulsed mode at the frequencies up to 25 KHz. In addition, it can be operated continuous wave (CW) and in a superpulse mode (up to 25 KHz) which provides approximately 1 kW peak power during the on-time of the pulse. All these modes are limited to average powers not exceeding 3.7 kW. The cavity is configured to produce beams with several different spatial modes including TEM₀₀, TEM₁₀, and TEM₂₀.

The sample was traversed under the laser beam using a CNC control system in conjunction with a five axis Aerotech workstation to provide constant linear translation of the workpiece. Several successive laser tracks were laid with overlap of 30% to achieve coverage of the entire surface. The laser beam was defocused by 10 mm above the surface to provide approximately 1 mm diameter on the sample surface.

The laser treatments were conducted with the assist gas of the mixture of hydrogen (15 vol%) and nitrogen (85 vol%). Such assist gas provided a reducing environment during the laser treatment and simultaneously prevented oxidation of the substrate material. The laser processing parameters employed during the treatment are given in Table 3.

Table 3. Laser Processing Parameters

Power	1400 watts
Beam Mode	TEM ₁₀
Beam Polarization	Circular
Traverse Speed	450, 300, 250, 200 cm/min
Focal Position	10 mm above surface
Shielding Gas	Hydrogen (15 vol%) + Nitrogen (85 vol%)

The laser treated samples were evaluated for topographical features using SEM and for elemental and phase analyses using EDS and X-ray diffractometry respectively.

The as-received sample being only 3 mm thick, it was not possible to further mechanically polish to smoother surface. The samples, therefore, prior to spray deposition of the powder, were only cleaned with alcohol and thoroughly dried.

The topographical features of such as-received sample are shown in Figure 2. Figure 2 is an SEM micrograph of as-received pure nickel substrate showing parallel machine groves on the surface. These groves are expected to provide mechanical

Figure 2. SEM overview showing surface topography of as-received pure nickel sample

anchoring locations for the powder particles which in turn eliminates the need to use binder to deposit the powder layer.

The surface overviews of laser treated samples with various traverse speeds are illustrated in Figures 3 and 4. These are the SEM micrographs showing the nature and the coverage of the MgO buffer layer. All these samples had pre-coat powder layer of about 6 μm . The dark regions on the micrographs represent MgO layer. Existence of such layer was detected using EDS (Figure 4b) which was further confirmed by X-ray diffraction analysis (Figure 5). The coverage of MgO layer appeared to have increased with decrease in traverse speed under the same laser power (1400 watts). The decreased traverse speed provided longer residence time for the beam which in turn provided thermodynamic conditions suitable for powder particles to fuse with the substrate.

In view of the above observations and in order to achieve buffer layer coverage on the entire surface, the samples were pre-coated with thicker layers (Table 2). Figures 6a, 7a, and 8a are SEM micrographs of the surface views of laser MgO buffer layer coated samples with thick pre-coats (about 40 μm) of powder layer. All these samples provided better coverage of MgO buffer layer which was confirmed both with EDS (Figures 6b, 7b, and 8b) and X-ray analyses (Figure 9). The pre-coat powder layer being very thick compared to the pre-coat layers (6 μm) used in earlier attempts, it appeared that there are optimum laser processing conditions for which the coverage was better along with the better adherence. Such optimum conditions within the present range of parameters appear to correspond to 300 cm/min traverse speed (1400 watts). As the traverse speed decreases further to 250 and 200 mm/min, the powder material seems to evaporate (Figure 8a) due to longer beam residence time (i.e. higher energy input). It is possible to change the laser processing parameters to obtain a combination for suitable energy input to deposit the buffer layer for full coverage of the entire surface which will be the next aim of the on-going efforts.

Based on above efforts, initial attempts were made to deposit YSZ buffer layer on pure nickel using exactly the same pre-coating method and laser processing parameters with very limited success. As shown in Figure 10, the layer coverage after laser treatment was extremely poor (Figure 10a), even though EDS analysis (Figure 10b) indicated the existence of the YSZ. It seems that different processing conditions will be required to explore the effective deposition of YSZ buffer layer.

The following tasks are proposed under the efforts for the next quarter.

1. Continue exploring additional combinations of laser processing parameters for creating uniform MgO buffer layer on pure nickel substrate.
2. Initiate efforts similar to that in Item 1, for buffer layers of YSZ and CeO_2 .

(a)

(b)

(c)

Figure 3. SEM micrographs showing the nature and coverage of the MgO coating. (a) sample #1, (b) sample #2, and (c) sample #3

(a)

(b)

Figure 4. The nature and coverage of MgO coating on Sample #4.
(a) SEM micrograph, and (b) EDS spectrum

Figure 5. X-ray diffractometry data on nickel laser coated with MgO buffer layer

(b)

Figure 6. The nature and coverage of MgO coating on Sample #5.
(a) SEM micrograph, and (b) EDS spectrum

(a)

(b)

Figure 7. The nature and coverage of MgO coating on Sample #6.
 (a) SEM micrograph, and (b) EDS spectrum

Figure 8. The nature and coverage of MgO coating on Sample #7.
(a) SEM micrograph, and (b) EDS spectrum

Figure 9. X-ray diffractometry data on nickel laser coated with MgO buffer layer

Figure 10. The nature and coverage of YSZ coating on Sample #12.
 (a) SEM micrograph, and (b) EDS spectrum

3. Develop a method to prepare and observe the coated buffer layer in cross section for thickness measurements and for studying the interface between the substrate and the buffer layer.
4. Make initial attempts to deposit buffer layer by in-situ delivery of the powder at the laser-material interaction region.
5. Explore other suitable assist gases to provide more effective and safe reducing environment during laser treatment.

OPEN ITEMS

A. UTSI: None

SUMMARY STATUS ASSESSMENT AND FORECAST

The CFFF continues in standby condition with preventive maintenance and repairs being accomplished primarily by funding from other DOE contracts.

High Temperature Superconductor work continued substantially as scheduled on the five subtasks (6.02 - 6.06) previously authorized and one additional subtask, 6.07, was authorized during the quarter.

Discharge water and waste disposal activities continued as scheduled. Groundwater remediation considerations were delayed awaiting a report from the consulting firm employed to make recommendations.

Next quarter work will continue in these areas with increasing emphasis on cooperating with commercial companies and national laboratories on the High Temperature Superconductor program. A groundwater report will be prepared by UTSI personnel.

TASK AND COST VARIANCES

The large positive variances in Tasks 1-3 were due to inadequate funding being provided to accomplish these tasks. Consequently, management actions were taken to restrict work performed to that available under the contract.

The positive variance in Task 6 is due to two factors. In direct labor, it is because of some delays in starting the projects and in delays in recruiting personnel, especially graduate research assistants. The positive variance in equipment purchases is due to delay in delivery of an x-ray diffraction system which is on order.

January 1, 1997 - March 31, 1997 QUARTERLY VARIANCE REPORT

Planned vs. Actual Expenditures
(thousands of dollars)

TASK	PLANNED	ACTUALS	VARIANCE
1	171.4	77.7	93.7
2	82.7	29.9	52.8
3	89.1	27.4	61.7
4	0.0	0.0	0.0
5	0.0	0.0	0.0
6	414.5	205.2	209.3
TOTALS	757.7	340.2	417.5
COST ELEMENT			
DIRECT LABOR	286.7	179.4	107.3
FRINGE BENEFITS	71.7	41.3	30.4
EQUIPMENT	148.2	0.0	148.2
EXPENDABLE MATERIAL	32.3	2.2	30.1
OUTSIDE CONTRACTS	9.2	3.4	5.8
TRAVEL	6.4	5.3	1.1
TOTAL DIRECT COSTS	554.5	231.6	322.9
INDIRECT COSTS	203.2	108.6	94.6
TOTAL	757.7	340.2	417.5

Planned vs. Authorized Funding
Cumulative

TASK	PLANNED	AUTHORIZED FUNDING
1	1040.0	
2	719.8	
3	504.3	
4	153.0	
5	118.0	
SUBTOTAL	2535.1	1103.2
6	1989.5	2198.5
TOTAL	4524.6	3301.7