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AND RELATED ACTIVITY

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EXECUTIVE SUMMARY

Routine preventive maintenance of the DOE Coal Fired Flow Facility (CFFF) is being performed. Modernization programs, funded under subcontract from Foster Wheeler Development Corporation by the DOE HIPPS Program, have been completed 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. A plan for Groundwater Remediation was prepared, coordinated with DOE and approved by the State of Tennessee. Actions are underway to dispose of spent seed/ash mixtures and excess coal remaining from the MHD POC program.

The status of five (5) High Temperature Superconductor (HTS) projects is reported.

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.

The high pressure natural gas system was used during the recent Westinghouse combustor test and the crankshaft of one of the two compressors failed during the test. Repair of the compressor crankshaft is underway and the manufacturer, Ingersoll-Rand, is also investigating to determine why this compressor has experienced two crankshaft failures in the past year. Ingersoll-Rand is repairing the compressor under warranty.

All of the remaining original CFFF control room consoles are being removed and planning has been initiated to integrate the coal system, process cooling water system, and downstream equipment into the new Distributed Control System (DCS). A new data plotting routine was developed for the new Distributed Control System.

A plan to reconfigure the radiant furnace for operation was started. The radiant furnace was partially disassembled in anticipation of a new furnace for the HIPPS program. Since the HIPPS integrated systems test program at UTSI has been canceled, the radiant furnace reassembly is being considered.

A purchase order was issued for annual electrical substation and transformer maintenance.

A government property inventory of CFFF was completed this quarter.

TASK 2 - REPORTING AND ARCHIVING

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 documents.

TASK 3 - SITE ENVIRONMENTAL COMPLIANCE AND REMEDIATION

Resolution of the remaining tote bins has not been resolved.

A large list of equipment has been retired such that obsolete equipment was accumulated for disposal. None of this equipment is considered hazardous waste. A large portion is simply metal racks, etc. that can be recycled.

Subtask 3.1 Implementation of State of Tennessee Groundwater Remediation Plan

Status

Monitor wells UTSI-2, UTSI-4, UTSI-5, were sampled between 2/26/96 and 03/14/96 for the Preliminary Ground Water Sampling Event. This was done in an effort to establish a list of target analytes for the remaining soil and/or ground water sampling events.

To date all of the wells had been properly sampled for the metals and chemicals listed in the source plans submitted and approved by the State of Tennessee by letter on November 10, 1997 from Mr. Keith Reinhardt. The approved source plans are included as Appendix A. However, Wells 11 and 13 will be sampled again for VOCs and phenol because the holding time for these chemicals was exceeded. Also, well #8 will be sampled for DRO due to sample bottles arriving broken. Refer to Figure 1 from the July-September 1997 Quarterly Technical Progress Report for well locations. Well samples for well numbers 11-16 were hand bailed using new uncontaminated one liter Teflon bailers. These bailers arrive sealed such that contamination from handling or in house cleaning is eliminated. Some results of the chemical analysis of the samples had not arrived by the end of the current quarter.

Results

Table 1 gives the complete chemical/metal sample scheme and listing. BDL indicates below detection limit and an "x" signifies that the result has not arrived.

Thus far only well #10 has exhibited contamination which is almost certainly from CFFF/ECF activities. This was the organic tetrachloroethylene at a level of 42 ppb. This well is located just below the field area that has demonstrated organic contamination in the past. The surprise here is that no other organic was detected, and the 42 ppb is an order of magnitude lower than expected based upon past results. Results from wells 11&13, which are also downstream of the contaminated SWMU, are due the week of 4/6/98.

At well #16 there was a small indication of the presence of phenol. The number 62 ppb was reported from the lab. The detection limit is 40 ppb, and lab personnel stated that the method was not that reliable at this level. Also, the lab indicated that there was a distinct possibility of external contamination. Plans are to sample this well again for phenol the week of 4/6/98.

Table 1. Results of Chemical Analyses for Constituents of Concern

	UTSI-2	UTSI-3	UTSI-4	UTSI-9	UTSI-10	UTSI-11	UTSI-13	UTSI-14	UTSI-15	UTSI-16
Carbon Tetrachloride				BDL	BDL	x	x	x	BDL	BDL
1,1-Dichloroethylene		30 ppb		BDL	BDL	x	x	x	BDL	BDL
Tetrachloroethylene				BDL	42 ppb	x	x	x	BDL	BDL
1,1,1-Trichloroethane		7.7 ppb		BDL	BDL	x	x	x	BDL	BDL
Phenols	41 ppb			BDL	BDL	x	x	x	BDL	62 ppb
Chromium			15 ppb	25 ppb	59ppb	BDL	19 ppb	x	17 ppb	27 ppb
Copper	140 ppb		24 ppb	17 ppb	BDL	BDL	BDL	x	BDL	14 ppb
Lead				7.9 ppb	16 ppb	BDL	9.4 ppb	x	5.6 ppb	15 ppb
Nickel			110 ppb	23 ppb	70 ppb	BDL	39 ppb	x	19 ppb	110 ppb
Zinc	98 ppb		130 ppb	42 ppb	140 ppb	17 ppb	70 ppb	x	28 ppb	100 ppb
Diesel Residual Organics - Well #8 Result Has Not Arrived										

The results for metals have not indicated elevated levels for any of the wells to date. There was one result for Cr at well #10 that indicated a level slightly above drinking water standards for metals. The standard is 50 ppb and the lab result indicated 59 ppb. Due to the acidic nature of the area groundwater, this is not unusual, and there is no reason to suspect contamination from metals at this particular site from CFFF activities. Also, past results have not indicated Cr contamination in this area. Please see Table 1 for complete results.

Well #7

Abandonment of well number seven, which the State of Tennessee agreed should be abandoned, was initially started on February 20, 1998. The well cap and casing were lifted completely from the PVC four inch well. The ideal way for this to be closed was to pull the entire well, screen and all, out of the ground, and this proved to be too much with our machine. Next an attempt was made to unscrew the top section of the well with a four foot pipe wrench. The wrench simply scraped off the PVC as it dug into the four inch pipe section. A few other ideas were discussed and finally on March 31, 1998 the well was sawed off at ground level and dirt poured into the well.

Well Flow

On February 19, 1998 well recovery rates were recorded at wells 11 & 13. Wells were pumped down and the height of water column was recorded as each well recovered. Although recovery rates for wells 9, 10, 14, 15 & 16 have not been officially documented, these wells exhibited adequate flow as well. Figure 1 shows a typical result for the #11 well flow (depth vs time). During the initial well development, wells 11, 13, 14, 15 & 16 were pumped and checked for recovery under the direction of the consultant from Ground Engineering and Testing Service, Inc. All wells were "flowing" and recovering to his satisfaction.

The main point of documenting adequate well recovery rate is simply to assure representative sampling can be conducted. For example, the required three well volumes before sampling were easily accomplished at all of the new wells.

Slug Tests/Hydraulic Conductivity

A summary of these tests was published in the July-September, 1997 Quarterly Technical Progress Report.

FIGURE 1. UTSI-11 SAMPLING WELL

Status of Soil/Diesel Excavation

This portion of the project has not begun. The expected start date is June, 1998.

Subtask 3.2 Monitor/Treat Holding Pond Effluent

Monitoring of the holding ponds and their effluent to the lake continues. No treatment was required during the quarter.

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 in the above project.

The topical report describing UTSI's evaluation of the candidate options was revised following comments and suggestions made during the review with DOE members. The revised version has been reviewed internally and it will be distributed as soon as we receive the approval and external distribution list from DOE/TPO (Dr. Udaya Rao). The technical paper that was prepared earlier for possible publication in the reputable journal is now being revised to incorporate all the changes made in the topical report.

Two technical abstracts have been submitted for possible presentation at the upcoming ASC-98 Conference to be held in September 1998 in Palm Desert, California. One abstract is based on the recently completed UTSI's process evaluation work and the other abstract is based on the ongoing bench scale dip-coating work utilizing the sol-gel concept. This bench scale development of the HTS coating scheme based on the

sol-gel concept is carried out jointly between UTSI and ORNL using a UTSI provided graduate research assistant.

A bench scale mode dip-coating unit has been assembled at UTSI. Using this new setup, one sample of SrTiO_3 single crystal was coated with LaAlO_3 precursor solution to test the system and to ensure epitaxy. Similarly, glassware necessary to prepare the precursor solutions at UTSI has been acquired and now it is being modified to provide additional openings to resemble the similar setup used at ORNL. Meanwhile the precursor solutions are being prepared at ORNL. A simple apparatus to measure the surface tension of the liquid precursor solution has also been acquired.

Additional results from the characterization of LaAlO_3 coated SrTiO_3 single crystals have been received. These are shown in Table 2 with the results reported earlier. These additional results were obtained for the experiments in which the substrate withdrawal speed was varied from 3 cm/min to 90 cm/min. From Table 2, one can see that within experimental scatter, as the sample withdrawal speed was increased, the FWHM and FWHM phi values increased. In case of FWHM values there was slight decrease before final increase; however, in case of FWHM phi values, there was a continuous increase with the increase in the withdrawal speed.

1. Thermal gravimetric analysis (TGA) was carried out to determine the weight loss during pyrolysis/thermal treatment of the LaAlO_3 coated SrTiO_3 substrates. This information is necessary to determine the oxide loading and density of the heat treated film. From the TGA experiment, for the precursor solution used in coating the given SrTiO_3 sample, the oxide loading value was determined as equal to about 7.3 wt. %.
2. Because the measurement of film thickness by the profilometry is difficult and the other methods such as TEM, (transmission emission microscopy), are lengthy, costly and time-consuming, attempts were made to measure the thickness of the coated samples by the SEM, x-ray reflectivity and laser light reflection methods. SEM and x-ray reflectivity methods depend on the smoothness of the substrate and could not differentiate between the substrate and buffer layers. The laser light reflection method showed some positive changes as shown in Figure 2. In this figure, the reflected power is shown as a function of the distance traversed along the coated sample; and one can see a distinct drop in the value of the reflected

power as the sample

Table 2. Preliminary Results from Batch Mode Dip-Coating Experiments Carried Out to Eval. Application of LaAlO₃ on SrTiO₃ Single Crystals by the Sol-Gel Method

Sample No.	Dh	Ts	Vw	Ta	Time	O ₂	FWHM	FWHM phi	Viscosity	tfilm	Day
VKL T01	1:1	20	3	800	5	21	0.188	0.343	2.5	1600	4
VKL T02	1:1	20	3	800	5	21	0.272	0.543	2.5	2200	4
VKL T03	1:1	20	33	800	5	21	0.277	0.46	2.5	6000	4
VKL T04	1:1	20	3	800	5	21	0.237	0.485	2.5	3000	7
VKL T05	1:1.2	20	33	800	5	21	0.187	0.347	2.5	5000	7
VKL T06	1:1.4	20	90	800	5	21	0.221	0.357	2.5	5000	7
VKL T07	1:1	20	3	700	5	21	0.235	0.36	2.5	1000	8
VKL T08	1:1	20	3	900	5	21	0.341	0.639	2.5	1200	8
VKL T09	1:1	20	3	800	1	21	0.195	0.437	2.5	1700	9
VKL T10	1:1	20	3	800	10	21	0.146	0.259	2.5	1100	9
VKL T12	1:1	20	3	800	5	100	0.157	0.281	2/5	1100	11
VKL T13	1:1	20	3	800	5	2			2.5	2500	11
VKL T14	1:1.2	20	3	800	5	21	0.188	0.336	2.5	1600	14
VKL T15	1:1.4	20	3	800	5	21	0.182	0.325	2/5	1000	14
VKL T17	1:1	40	3	800	5	21	0.233	0.489	2.5		15
VKL T18	1:1.4	20	3	800	5	21	0.27	0.679	2.5	2200	28
VKL T19	1:1.4	20	33	800	5	21	0.411	0.856	2.5	4000	28
VKL T20	1:1.4	20	90	800	5	21	0.26	0.534	2/5	3500	28
VKL62	1:1.4	20	3	900	10	4%H2-humid	0.383	0.567	2.5		44
VKL64	1:1.4	20	3	800	10	4%H2-humid	0.377	0.611	2.5		44
VKL66	1:1.4	20	3	800	10	4%H2	0.308	0.687	2.5		44
VIKL68	1:1.4	20	3	1100	20	4%H2-humid	0.301	0.752	2.5		44
VKL115	1:1.2	20	3	800	10	21	0.335	0.396	2.5		130
VKL116	1:1.2	20	15	800	10	21	0.232	0.875	2.5		130
VKL117	1:1.2	20	33	800	10	21	0.233	0.815	2.5		130
VKL118	1:1.2	20	70	800	10	21	0.445	1.101	2.5		130
VKL119	1:1.2	20	90	800	10	21	0.557	0.964	2.5		130

Dh: Degree of hydrolysis Vw: Withdrawal velocity (cm/min) Time: Annealing time(min) FWHM: FWHM for omega scan Viscosity: Viscosity of the solution (cps) Ts: Solution temperature (°C)
Ta: Annealing Temperature(°C) O₂: Percentage oxygen FWHM phi: FWHM for phi scan tfilm: Thickness of the coated film (nm) Day: Number of days from day of solution preparation (e.g. ageing characteristics)

Reflected Power vs. Distance Along Sample

Figure 2. Reflected Power vs. Distance Along Sample

was traversed from one end to the other end at two different incidence angles. The thickness of the coating varies along the sample because of small sample length used in the coating experiments. This thickness variation may have possibly caused some variation in the absorption of the incident laser light which would result in a decrease in the intensity of the reflected light. Another explanation for the reduction in the intensity of the reflected light is that the increased path length for the transmitted light through the coating causing the light reflected from the coating and interface with substrate (SrTiO_3) to be out of phase and thereby resulting in decreased intensity. This observed phenomenon is being evaluated further to quantify it with the film thickness and to explain the physics involved using principles of optics.

3. Experiments to systematically evaluate effect of major variables in coating of YBCO film over LaAlO_3 and YSZ single crystals have been initiated. Also, arrangement has been made with the ORNL to acquire rolled and annealed samples of nickel substrate to carry out similar parametric variation experiments.

Subtask 6.03 Coated Conductor Development and Program Management

During this quarter a cooperative agreement was negotiated with EURUS Technologies, Inc. This agreement is to cooperate in two areas. The first area is to support the development of texturized nickel substrate. The Plastronic Division of EURUS is working with the parameters necessary to optimize nickel substrate. UTSI will support this work by providing laboratory analyses (x-ray diffraction, scanning electron microscopy and other laboratory support) on samples prepared by EURUS. In addition, UTSI will apply buffer layers and YBCO superconductor to selected nickel substrate samples by the Sol Gel method. EURUS will attempt to apply YBCO to samples with Sol Gel buffer layers for performance evaluation by both UTSI and EURUS.

A second area of cooperation is in optimizing the rolling and annealing process for the nickel substrate. A matrix of parameters concerning the physical processing of the nickel strips will be used by EURUS in preparing samples. UTSI will conduct a systematic study of annealing conditions for these samples and evaluate the crystalline structure in order to select the best substrate processing conditions.

Subtask 6.04 Optimum Coated Conductor

The atomic force measurements (AFM) of micro machined nickel samples at ORNL are proceeding well. There was a problem earlier in the quarter of getting oxidation on the samples during annealing. This problem has been solved by switching to an annealing furnace with a better vacuum capability. Images of the 800°C, 10 min annealed sample

have been made, and measurements are currently being taken from these images. The current plan is to make approximately 1,500 dimensional measurements for each sample.

Three meters of silver sheathed Bi(2223) tape were procured and received from BICC Cables. The tape is multi filament tape having a critical current of the order of 20 amps. The tape will be divided into three, one meter lengths to measure the effects of interconductor spacing on transport current losses. A suitable cold box for making the measurements is being designed and instrumentation and power supplies for performing the measurements is being sought. The initial measurements will be to characterize the critical current density of the three lengths separately. It is expected that the procedures developed will be applicable to YBCO tapes when they become available in meter lengths. A write-up of the experimental plans is in progress.

Subtask 6.05 Cost/ Performance Analyses of Potential Manufacturing Processes

Work on this subtask for the quarter was principally in developing a life cycle cost comparison between HTS production using the electron beam process for deposition of the YBCO and the Pulsed Laser Deposition(PLD). As is well known, most of the good quality superconducting thin films produced to date have used PLD to apply the superconducting layer. There are a number of factors, however, that indicate that it may not be the best choice for large scale commercial production of thin film superconducting wire or "coated conductors" as they have been named. Among these factors are:

- a) The Excimer laser used in this process is relatively low power (around 50- 200 watts) and expensive, costing around \$2,800/watt of power on the target. The continuous electron beam, by contrast, costs around \$1.50/watt of power on the target.
- b) The PLD process uses YBCO which is vaporized and depos-

ited on the substrate in the same form. The electron beam system vaporizes Yttrium, Barium and Copper in the correct amounts and deposits them on the substrate with the correct oxygen supply to form YBCO. As a result, the material costs for the electron beam deposition process are less than half that of the PLD.

- c) Because the electron beam uses elemental inputs (Y, Ba and Cu), it is believed necessary to measure the stoichiometry for these inputs and control them to get the correct YBCO compound.
- d) The PLD system is pulsed and vaporizes a small amount of the target but the surface returns to normal between pulses. The electron beam, in contrast, is continuous so that there is a tendency to melt the material in the target pot and may also incur large heat losses to the water cooled pot walls. Thus the efficiency of using the vaporization source energy is lower in the electron beam case but is at least three orders of magnitude cheaper.

The production processes compared are similar in all respects except the process that applies the superconductor. Both use rolled nickel, annealed in the same manner as believed to be representative of the ORNL RABiTS process. Both processes use electron beam web coaters to apply Cerium Oxide and YSZ buffer layers epitaxially, 100 Angstroms in depth. An annual production rate of 18,000,000 meters/year of double sided 2 micron YBCO with a J_c of a million amps/cm² is assumed.

The estimated capital costs for the two plants are shown in Table 3. The capital costs were obtained from manufacturers of the equipment required where possible. In other cases, prices from catalogs were used, scaled to the correct size by the 0.6 exponent method. In the case of the passivation/insulation layer, it likely depends on the application of the wire. Funds were estimated to provide an insulation layer similar to that used on copper magnet wire currently.

The cost estimates for the vacuum chambers for both processes were based on several calculations and judgements that become assumptions for the study. A calculation of the energy required to heat the materials to the vaporization point, vaporize them and then superheat to 3400 K yielded about 5,500 watts. This number does not include any inefficiencies such as radiation, heating the walls of the pots and chamber

and heating material in the pot that is never vaporized. The chamber was sized for a single electron beam to have a deposition area of 50 cm by 30 cm, representing a deposition solid angle of 10.6 % of a hemispherical surface. For PLD, it is estimated that 80 lasers are required. A configuration was not developed in which all these lasers and sufficient YBCO boat area could be available in a single chamber. Instead, eight chambers were chosen with ten lasers working in each. This has a major effect on the capital costs and should be the subject of more detailed examination if PLD is otherwise an attractive choice. The higher vacuum needed by the electron beam system was taken into account but it is anticipated that most of the process material will deposit out as solids on the chamber walls and elsewhere. As can be seen from Table 3, the PLD capital costs are almost three times as large as the electron beam facility.

In this study, a 30 year lifetime has been assumed for the plant. Depreciation, taxes, insurance and working capital are calculated at 18% of the capital costs annually. Maintenance and facility modification costs are estimated at 10% of the capital costs annually.

Table 3. Estimated Capital Costs for Production Processes

Capital Cost Category	Electron Beam	PLD
Rolling Mill	150,000	150,000
Heat Treatment Facility	443,000	443,000
E-beam Web Coater	4,000,000	4,000,000
E-beam-YBCO	1,419,000	0
PLD-YBCO	0	41,500,000
Vac Cham for YBCO	1,382,616	5,330,600
Monatomic Oxygen S	402,000	0
Oxygen Monitor	52,000	0
Environmental Treatment	100,000	100,000
Passivation/Insulation	1,000,000	1,000,000
Tape Handling System	500,000	500,000
Control Systems	6,209,000	4,109,000
Laboratory/QA Test Facility	1,500,000	1,500,000
Site & Development	550,000	550,000
Elect. Substations	1,000,000	1,000,000
Buildings	3,720,000	3,720,000
Sub-total	22,427,616	63,902,600
AE Fee @ 15%	3,364,142	9,585,390
Sub-total, \$	25,791,758	73,487,990
Contingency @ 20%, \$	5,158,352	14,697,598
Total Capital Cost, \$	30,950,110	88,185,588

Material cost estimates are shown in Table 4. Labor cost are based on estimated staffing requirements and total 137 personnel for the electron beam system and 152 for the PLD. With estimated utilities added, the total

annual cost is estimated at 28.7 million dollars for electron beam and 54.2 million dollars for PLD. Dividing this by the 18 million meter annual production gives a cost per meter of \$1.59 and \$3.01, respectively. If the desired J_c of a million amperes/cm² is achieved, the wire carries 400 amperes and the cost per kiloampere meter becomes \$3.99 for the electron beam and \$7.52 for the PLD.

These results are encouraging in terms of the national plan cost objective of less than \$10/kA-m, however there are significant uncertainties in terms of the technology that need further development. One of the largest uncertainties is quality versus deposition rate. The deposition rates implicit in these capital costs are higher than any achieved to date but less than some advocates have suggested may be possible.

Table 4. Materials Cost			
Materials Cost	Unit Cost	Ebeam Annual Cost	PLD Annual Cost
Nickel	\$38.27/kg	2,330,000	2,330,000
Yttrium	\$345/kg	2,049,000	
Barium	\$125/kg	2,300,000	
Copper	\$41/kg	523,560	
Cerium	\$394/kg	79,082	79,082
YSZ	\$1,298/kg	246,865	246,865
YBCO	\$300/kg		13,338,000
Gases, Supplies		500,000	500,000
Sub Total Materials, \$/yr		8,028,507	16,493,947

Subtask 6.06 Development of Real Time Process Control Using InSitu Diagnostics

Spectroscopic Absorption Studies

A literature search has been conducted in support of using molecular absorption spectroscopy to determine

concentrations of the Yttrium, Barium and Copper THMD precursors for the MOCVD process. IR absorption spectra of Y(THMD)₃, Ba(THMD)₂ and Cu(THMD)₂ are available, and detailed absorption lines useful for absorption spectroscopy are identified in the 6-8 micrometer wavelength region. It also appears that UV lines may exist in the 200-400 nm wavelength region, and because detectors for the UV may be more appropriate for on-line diagnostic measurements, an experiment is being set-up to detail existing UV absorption from the three precursors. An oven to vaporize the precursors and a scanning spectrophotometer to identify absorption lines were placed in the laboratory area for these experiments, and the experimental process has been designed for the first trials. The relatively high temperature, modest vacuum absorption cell has been specified and assembly of it is currently out for bid. The basic optical system has been designed to allow a single or triple pass of the deuterium lamp emissions through the cell to the scanning monochromator. Design of optical access windows has also been completed and bids for them have been requested. Design of the cell vacuum system is progressing, and optical elements are being ordered. It is anticipated that experiments will be initiated early next quarter, shortly after the vacuum cell arrives. Experiments with known gas sources will be conducted initially. Techniques for determination of precursor concentrations in the cell to allow calibration of the absorption measurements is still being investigated.

Raman Spectroscopy

This quarter work has continued on the study of Raman spectroscopy as a tool for analyzing high-temperature superconductor films, buffer layers, and substrates. Initial emphasis was placed on obtaining Raman spectra from YBCO samples. Raman spectra of YBCO films has been shown to provide information about the crystal orientation and oxygen concentration. Raman scans have been performed on available samples of a single YBCO film and YBCO blocks but results have been inconclusive. More suitable samples will be needed to expand this part of the Raman study.

Many problems have been addressed in the Raman lab that slowed progress at the beginning of the quarter. Power was turned off to the building which houses the Raman lab due to ongoing campus electrical distribution improvements and facility renovations. A temporary power line was run from a nearby building for the argon ion laser being used in the lab and a generator was placed outside the lab to supply power to the rest of the lab. Problems were encountered with the generator which could not supply a steady voltage to the equipment and several pieces of equipment had to be repaired. Eventually the generator was removed and power is now being supplied from another building.

Once the lab received a good source of power all electronic components involved with the actual photon counting were examined to ascertain that components had not been degraded by the power difficulties. The amplifier/discriminator was adjusted to decrease noise sensitivity. Improvements were made in the computer program used to acquire Raman data to give more precise count rates. Finally, the whole photon counting circuitry was tested via experiment and it was determined that it was operating as expected.

After repair of the systems Raman scans were performed on two calibration samples, diamond and sulphur. The appropriate Raman lines were found for each of the samples. Examples of these scans are included in Figures 3 and 4. The single Raman line in diamond is very intense and all the Raman lines from the sulphur sample were strong and shifted appropriately as shown in other references.

The Raman spectroscopy setup used for these samples contained only one lens which focused the laser

light onto the sample and then back onto the entrance slit of the double spectrometer. Very good data was provided with this setup. The diamond scan was done using this setup as well as one of the sulphur scans included here.

Figure 3. Sulfur Calibration Scans

Figure 4. Diamond Calibration Scan

While usable data was obtained with the single lens optical configuration, improvements in system performance were sought with a second optical system. The second setup tested included an additional lens placed in front of the entrance slit to focus the scattered light onto the slit allowing for greater throughput and increased signal by matching the $f/\#$ of the spectrometer to that of collection optics. A scan performed on sulphur using the improved optical system showed an increase in signal as can be seen in Figure 3. Figure 5 illustrates the new Raman optical system. This setup is now being used with all samples and in some cases compared to the simpler single lens setup.

Figure 5. Improved Raman Optical System

Work is continuing on studying the possible buffer layers used in manufacturing the HTSC films. Single crystal samples of lanthanum aluminate, cerium oxide, magnesium oxide, and yttrium stabilized zirconia have been ordered. Some samples of lanthanum aluminate on strontium titanate have been obtained from the work under subtask 6.2 and work has progressed on one these. Raman lines have been found on the lanthanum aluminate. A Raman line has also been identified in the substrate spectra. Polarization studies are being done on the sample.

Recent work has suggested that Raman spectroscopy could be used to find layer thickness of these samples via the intensity of the lanthanum aluminate and strontium titanate spectra features. Graphs of two lanthanum aluminate scans are included in Figures 6 and 7. One scan was done on what appeared to be a denser spot of the layer and the other scan was performed in an area of little or no lanthanum aluminate. Notice the distinct Raman line from the substrate and the two lines from the layer. There appears to be a definite relation between

the ratio of the two types of Raman lines and layer thickness. As the layer thickness of the lanthanum aluminate decreases the two Raman lines from it decrease and the Raman line from the substrate becomes more intense. Presently the thickness of the lanthanum aluminate layer can only be studied qualitatively. By moving the sample around on its stage and allowing different areas of it to be Raman excited an overall relative assessment of layer thickness can be found. With a few samples of known thickness a technique could be easily developed to determine quantitatively the layer thickness of these samples and possibly lanthanum aluminate samples on any substrate.

More scans are being done to determine the polarization dependencies of these specific samples for information on crystal orientation. If information can be found in this area the Raman technique could be used to give data on layer thickness and layer quality for lanthanum aluminate layers.

After receipt of the other samples (cerium oxide, magnesium oxide, and yttrium stabilized zirconia), scans will be performed on those for similar information and the Raman spectra assessed for features that can be used for measurements of layer quality and thickness. If the Raman scatter is sufficiently strong, such as from the lanthanum aluminate sample, an on-line industrial process could be developed.

Future work will continue with these four different types of buffer layer material. Polarization studies will continue on the lanthanum aluminate.

Scatterometry

During the last quarter, a basic commercial optical scatterometer (Schmitt Finish Measurement System (FMS)) was selected for use in surface roughness measurement and DOE purchase approval requested. The instrument employs a limited set of detectors and thus can not supply the complete PSD of the examined surface but does allow rapid determination of surface roughness figures. The instrument uses a solid state emitter (laser diode) and four fixed detectors and is capable of roughness measurements in the range of 5 - 2500 Angstroms at a rate of 500 measurements/second. The system is designed to be suspended near the surface to be examined as the material passes by the detector head. The system is simple and rugged and thus suitable for use in either an industrial or laboratory environment.

Figure 6. Raman Scan of Lanthanum Aluminate

Figure 7. Raman Scan of Strontium Titanate Substrate

Further improvements were made in our laboratory capability to make full bidirectional reflection distribution function (BRDF) measurements. Equipment and optical components were purchased to allow general full hemispherical reflection measurements. Such measurements are necessary to fully characterize the expected scatter from the various HTSC layers as the initial steps for developing measurement criteria for distinguishing defective HTSC layers. All required items are expected during April and initial measurements from the improved system will be made during the next quarter.

OPEN ITEMS

A. UTSI: None

B. DOE/FETC: Topical Report entitled, "Evaluation of Methods for Application of Epitaxial Buffer and Superconductor Layers" sent for final review and specification of distribution.

Property Retirement Work Order Authorization #15 - #30 have been sent for processing.

SUMMARY STATUS ASSESSMENT AND FORECAST

The CFFF continues in a standby status with preventive maintenance and repairs being accomplished as funding permits. Utilization of the facility for other work, with DOE authorization, provides assistance in maintaining operational capability. Currently, tests of the Westinghouse Electric Corporation topping combustor are the only tests scheduled in the facility.

High Temperature Superconductor work continued substantially as scheduled on the five subtasks (6.02 - 6.06) previously authorized. Additional cooperative programs are being discussed.

A Source Plan for groundwater remediation at the CFFF was approved by the State of Tennessee this quarter. Initial actions were completed under this approved plan.

TASK AND COST VARIANCES

The variance in Tasks 1 - 3 continue to be positive because the available funding level is below the Management Plan level for these tasks.

The positive variance in Task 6 reflects management decision to reduce FY-98 expenditures below Management Plan levels.

APPENDIX A

PHASE III UTSI GROUNDWATER INVESTIGATION

APPROVED SOURCE PLANS

PHASE III UTSI GROUNDWATER INVESTIGATION

SOURCE PLAN #1 PETROLEUM SOURCE

- 1) Sample well #8 for TN Diesel Range Organics (DRO) and Total Petroleum Hydrocarbons (TPH). This will be completed to assure that groundwater migration does not include diesel fuel contamination from fuel storage area located above well #8. Sample analysis will be completed by a lab certified for drinking water.
- 2) Excavate areas of known diesel fuel contamination.
- 3) Sample at appropriate depths after excavation to determine that contaminated soils have been removed.
- 4) The soils will be staged at our facility, and treated in accordance with UST Technical Guidance Documents 009 & 005 as applicable for on site treatment. A copy of each was sent as an attachment in the prior letter.
- 5) The soils will be sampled periodically (e.g., monthly) until levels are within guidelines such that they may be either removed or returned to their origin. The DRO analysis will be completed by a lab certified for drinking water.

SOURCE PLAN #2
ORGANIC MATERIAL SOURCE

- 1) Perimeter wells (9, 10, 11, 13, 14, 15, 16) will be sampled for the constituents of concern as shown in the table sent in the prior letter. The basis for these constituents is due to the findings in the analyses shown in Appendix C in the groundwater (GW) report, "Phase II Site Investigation" completed by Ground Engineering and Testing Service, Inc., dated May 9, 1997. These samples will be sent for analysis to a lab certified for drinking water.

NOTE: Perimeter well #12 was abandoned after drilling into a two inch water line during the first few feet, and therefore, not included in the above sampling routine.

- 2) UTSI suggests that Well #7 as shown on the sketch in the prior letter be abandoned. The well has little production which is indicative of well screen plugging.

Also, and more importantly, two new wells (See sketch, wells #11 & #13) were installed, clustered around well #7 such that GW monitoring will be representative of the area of concern. The new wells are producing as expected in comparison with the other wells.

- 3) Based upon the analysis of well sampling for constituents of concern, UTSI will propose a further strategy.

January 1, 1998 - March 31, 1998 QUARTERLY VARIANCE REPORT

Planned vs. Actual Expenditures
(thousands of dollars)

TASK	PLANNED	ACTUALS	VARIANCE
1	201.9	123.1	78.8
2	95.9	23.6	72.3
3	77.2	22.3	54.9
4	0.0	0.0	0.0
5	0.0	0.0	0.0
6	451.0	270.0	181.0
TOTALS	826.0	439.0	387.0
COST ELEMENT			
DIRECT LABOR	338.5	232.9	105.6
FRINGE BENEFITS	84.6	50.3	34.3
EQUIPMENT	115.3	0.0	115.3
EXPENDABLE MATERIAL	33.8	7.3	26.5
OUTSIDE CONTRACTS	9.9	2.0	7.9
TRAVEL	7.1	4.8	2.3
TOTAL DIRECT COSTS	589.2	297.3	291.9
INDIRECT COSTS	236.8	141.7	95.1
TOTAL	826.0	439.0	387.0

Planned vs. Authorized Funding
Cumulative

TASK	PLANNED	AUTHORIZED FUNDING
1	1796.3	
2	1081.8	
3	843.6	
4	153.0	
5	118.0	
SUBTOTAL	3992.7	1807.7
6	3746.4	3351.3
TOTAL	7739.1	5159.0