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CARBIDE CATHODE STUDIES
PHYSICAL AND CHEMICAL REDEPOSITION

QUARTERLY PROGRESS REPORT
FOR THE PERIOD APRIL 1, 1962, THROUGH JUNE 30, 1962

Contract NAS 3-2301
National Aeronautics and Space Administration

July 18, 1962

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DIVISION OF
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ABSTRACT

The utilization of physical and chemical processes to reduce the rate of vapor loss of thermionic emitters composed of mixed carbides of uranium and zirconium in order to increase the permissible operating temperature is being studied. Preliminary, qualitative results obtained from study of physical redeposition processes have shown that increasing the collector temperature may markedly reduce the rate of weight loss from a UC emitter operating at 2053°K . The requisite experimental equipment for studies of chemical transport processes has been designed and constructed. Experiments will proceed through both a physical chemistry approach to an understanding of the transport processes and a technique to evaluate the efficacy of possible combinations of chemical species by monitoring the electron emission from diodes containing such mixtures.

I. INTRODUCTION

This second quarterly progress report under Contract NAS 3-2301 covers work accomplished during the period April 1, 1962, through June 30, 1962.

The usefulness of thermionic cathode materials depends upon whether usefully long lifetimes (10,000 hr or longer) can be realized in the temperature range in which the electrical output is of practical interest, i. e., greater than several watts per square centimeter. If the operating temperature of an emitter could be raised even higher than the minimum set by the above criterion, additional gains would be realized in the form of increased electrical output and increased Carnot efficiency. In the case of unclad carbide emitters, not only does vaporization limit the life of the cathode, but it also increases thermal radiation losses by blackening the anode surface and thus increasing its thermal emissivity.*

The goal of the program under the current contract is to increase the operating range of emitters composed of mixed carbides of uranium and zirconium by reducing their rate of vapor loss through the utilization of physical and chemical techniques. The physical process being investigated is the possible suppression of condensation on the anode by raising the anode temperature above some critical temperature to be established as a function of:

1. Emitter temperature.
2. Collector temperature.
3. Interelectrode spacing.
4. Collector material.
5. Emitter material, i. e., U:Zr ratio.

Chemical processes being investigated are the use of chemical transport media to react with the effusing species either during their transit through the interelectrode space or upon their arrival at the collector to form a volatile compound which can be transported back to the emitter and which can decompose there as a result of the higher temperature. Such processes are used in the deposition of iodide metals or pyrolytic graphite. The variables listed above for the physical redeposition process are also common to the study of chemical transport, and in addition the following must be added:

* If the collector surface is covered by a low-emissivity cesium coating, this may be of only slight importance.

1. Gas species present as transport media.
2. Partial pressure of each gas species present.

Chemical species selected for study have been the halides for transport of the metal atoms and hydrogen for carbon transport by the methane reaction.

The physical or chemical transport process selected must also be compatible with the other requirements of a plasma diode:

1. The deposits must be uniform to prevent shorting of the inter-electrode space.
2. Diode components must not be sacrificially attacked.
3. The total pressure in the diode must be low enough to prevent excessive electron scattering; i. e. , there should not be a high internal resistance.
4. Sufficient cesium ions must be present to overcome space-charge limitations.
5. The chemical species present must not adversely alter the work functions of the emitter or collector.

The major emphasis during this reporting period has been on readying the requisite experimental apparatus. Construction of an experimental cell for chemical redeposition studies was complicated by the requirement that none of the components should be attacked by the halogens present. Difficulties encountered in the use of Kovar glass-to-metal seals have been eliminated by redesign of the cells to eliminate all Kovar seals. An additional cell has been constructed for studying the effect of chemical additions on the life of carbide emitters by monitoring their electron emission. Preliminary studies of physical redeposition processes have qualitatively illustrated that running the collector at a sufficiently high temperature can markedly reduce the rate of vapor loss from the emitter. Thermodynamic calculations have been conducted to establish the feasibility of using proposed chemical species as transport media.

II. EXPERIMENTAL PROCEDURES AND EQUIPMENT

CHEMICAL REDEPOSITION

A cell designed for the study of chemical transport phenomena related to carbide redeposition was described in a previous report.⁽¹⁾ Construction of this cell was complicated by the incompatibility of many materials with the halides which will be employed for the transport process. In particular, the cell design included two Kovar glass-to-metal seals. Kovar, being an iron-base alloy, is severely attacked by halides; but it was thought that plating the Kovar with nickel or platinum would satisfactorily prevent attack. Many attempts were made to plate these seals, both at the Laboratory and by commercial platers, but none was completely satisfactory--especially right at the junction of the Kovar to the glass. Although this method could perhaps have been pursued further, it was decided to utilize this cell (containing Kovar seals) for the physical redeposition studies which will be prosecuted in vacuum and to design another cell for chemical redeposition studies to eliminate all Kovar glass-to-metal seals.

The new cell design is illustrated in Fig. 1. Elimination of the Kovar seals has been achieved by the utilization of tempered Pyrex pipe with an O-ring groove and a Teflon gasket held in position by a metal flange assembly. The only metals now in contact with the halogens are Monel, iridium-plated tungsten, and nickel. Construction of this cell was completed at the end of the reporting period, and it is shown in Fig. 2.

Construction of the gas-handling system described in Ref. 1 has been finished. All components required for these studies have now been completed, and the initiation of experimentation is imminent.

Experiments have been conducted to establish that induction heating of the carbide sample can be used to temperatures of about 2000°C with chlorine gas present.

EMISSION-TRANSPORT STUDIES

Concurrently with the study of chemical transport processes from a physical chemistry approach, a cell is being built for studying the effect of chemical additions on the life of carbide emitters by monitoring their emission. This second approach will not be a substitute for the quantitative data obtained from the chemical studies, but will rather serve to screen

Fig. 1--Cell for chemical-redeposition studies

Fig. 2--Experimental arrangement for chemical redeposition: (left) emitter-collector arrangement; (right) complete assembly

various combinations of cesium, hydrogen, and halides to determine which systems shall receive the thorough, more detailed studies required for understanding and optimizing the redeposition process.

The cell to be employed is shown schematically in Fig. 3, and a photograph of the cell components is presented in Fig. 4. The cell consists of two major parts: (1) the emitter assembly, consisting of carbide powder electrophoretically deposited on two 7-mil tungsten filaments, and (2) a collector made by coating the inside of a glass cell with platinum ("Liquid Platinum" is painted on and then baked). The electrophoretic deposition will be done in situ after the cell is assembled to avoid undue handling of the coated filaments.

After evacuation and sealing of the cell, one of the duplicate filaments is heated to the desired temperature by means of a half-wave rectified direct-current power source, and its vacuum electron emission is measured. Initially, the emission will be characteristic of the carbide coating; but, owing to vaporization, ultimately the carbide will leave the tungsten filament and the emission will become characteristic of tungsten. The elapsed time, t_1 , required for the change in emission from that characteristic of the carbide to that characteristic of the tungsten will be noted.

Chemical additives to serve as chemical transport media are now admitted into the cell, and the second filament is heated to the desired temperature. The time, t_2 , required for the emission characteristics of this filament to change to those representative of the tungsten is measured. During this stage of the experiment the whole cell is maintained at the temperature required to provide the desired partial pressure of the chemical additives.

The difference between t_2 and t_1 , Δt , represents the efficacy of the additives in prolonging the life of the emitter. Variables studied will be emitter temperature, collector temperature, the spacing between emitter and collector, and the nature and pressure of the additives.

The cell components have been completed and the electronic equipment for following the emission change has been assembled. The only thing remaining to be done before measurements can begin is to establish the conditions under which the tungsten filament can be coated with a uniform, thin layer of the carbide by electrophoretic deposition. Initial work to establish the proper conditions for obtaining a uniform coating was conducted with ZrC powder, since it is not as pyrophoric as UC powder. The experimental arrangement employed a platinum-gauze cylinder connected to the positive terminal of a direct-current power supply and a 10-mil tungsten wire connected to the negative terminal. A suspension of carbide powder in an organic solvent was used as the electrolyte. The nature

Fig. 3--Emission-redeposition cell

Fig. 4--Components of emission-redeposition cell

of the deposited layer was determined by visual observation, and its thickness was calculated on the basis of the weight of carbide powder deposited. The solvent in which the ZrC powder was suspended was iso-butyl alcohol with a trace amount of HCl added. The factors studied were the size of the ZrC particles, the time of deposition treatment, and the predeposition annealing of the tungsten filament. Results obtained can be summarized as follows:

1. Finer powder yielded a more uniform coating. For example, ZrC powder passed through a 400-mesh sieve ($38\ \mu$) covered only 70% of the filament surface, while ZrC powder passed through a $14\text{-}\mu$ sintered glass filter covered 100% of the filament surface after the same time of deposition (5 min).
2. For a given size of ZrC particles, the surface coverage of the filament increased with the time of deposition. However, the coarse powder yielded a rougher surface.
3. The thickness of the coating increased approximately linearly with time during the initial stage of deposition. However, the results indicate that the rate of increase slowed gradually as the deposition proceeded further, presumably because of the exhaustion of the supply of fine particles in the suspension. A coating thickness of $5\ \mu$ has been repeatedly obtained, which should be adequate for the planned redeposition study.
4. Powder coated on an unannealed tungsten wire tended to be detached from the filament during heating in vacuum, while powder coated on a tungsten filament which had previously been vacuum-annealed for 15 min at 1800°C adhered very well upon subsequent heating.

At the suggestion of G. Haas of the Naval Research Laboratory, anhydrous methyl alcohol is being substituted as the carrier for the deposition of UC powder. Initial work with UC powder indicates that the characteristics of the coating are dependent upon the same variables, and in the same fashion, as were established for the ZrC powder. The main problem is obtaining a fine enough particle size. Both sieving and gravity settling techniques are being used for particle separation. As soon as optimum coating conditions are established, the filaments in the cell shown in Fig. 3 will be coated, and experimentation will be initiated using a Cs-CsF mixture as the transport medium.

PHYSICAL REDEPOSITION

Using the cell described in Ref. 1, studies of physical redeposition processes have been initiated. Initial experimentation is being conducted using a UC pellet at 1800°C and with a 20-mil space between the pellet and the collector. The collector is cooled by nitrogen or helium to maintain

the desired surface temperature. The collector temperature is monitored by a thermocouple which is inserted through the hollow support tube and rests a distance of 0.030 in. from the collector face. Runs are conducted for 2 hr in vacuo. After being cooled, the collector is removed and examined visually. The condensate is then removed by dissolution in HNO_3 .

Analysis of the uranium content in this solution is made by neutron-activation techniques. This procedure is fully discussed in Ref. 2, and the sensitivity for uranium is shown to be 5×10^{-9} g. Briefly, our sample is placed in General Atomic's TRIGA reactor, together with a standard sample. During irradiation the U^{238} is transmuted to U^{239} , which then decays to Np^{239} . The irradiation is at a 250-kw level for 20 min. The Np^{239} has a 2.3-day half life, which allows one to wait for several days after the irradiation before counting, in order to get rid of any short-half-life isotopes which may cause confusion in the analysis. Counting is done with a scintillation counter.

In addition to chemical analyses, the weight loss of the carbide pellet is determined for each run. However, this is of only secondary importance, since except for the one face of the pellet that faces the collector, vapor loss will be in accordance with Langmuir free evaporation; i. e., once an atom leaves the surface it will not be returned.

III. EXPERIMENTAL RESULTS

During this reporting period, the main emphasis has still been upon readying the experimental apparatus. However, preliminary study of physical redeposition processes has been initiated.

Three runs have been completed in which the simulated cathode was a UC pellet at $\sim 1800^{\circ}\text{C}$ and the spacing between the carbide pellet and the collector was held constant at 20 mils. The collector was platinum-plated Monel. An additional run was made with no collector present to establish the rate of weight loss under Langmuir free-evaporation conditions. After these runs were completed and analyzed, several errors in experimental procedure became apparent which necessitate that the data obtained be considered in a qualitative rather than a quantitative manner. These procedural errors are:

1. The collector was larger in diameter (1.27 cm) than was the carbide pellet (0.851 cm); in this geometric relationship, some of the atoms effusing from the sides of the pellet would hit the hot anode in addition to those vaporizing from the surface of the pellet facing the collector. The surface area of the pellet being influenced by the hot anode is therefore not defined and quantitative analyses cannot be performed.
2. Since the collector was larger than the emitter and was being heated primarily by radiation from the emitter, a temperature gradient must have existed between the center and the periphery of the collector. Isothermal conditions were not obtained, and the collector temperature was not uniquely defined.
3. The thermocouple in the center of the collector tip was exposed to the coolant gas stream and gave erroneously low temperature measurements.

Data obtained are presented in Table 1. The collector temperature is denoted by two values, one measured by the thermocouple in the interior of the tip and one measured by a thermocouple at the exterior periphery of the collector tip (see Figs. 5a and 5b). As discussed above, the temperature is not really defined by either of these values. However, one can determine the relative order of collector temperatures from the rate of gas flow and the temperature of the inside thermocouple; i. e., the highest collector temperature was obtained in run 1 and the lowest collector temperature in run 3.

Table 1
RESULTS OF PHYSICAL REDEPOSITION STUDIES*

Run	Emitter Temp. (°K)	Duration of Run (hr)	Collector Temperature (°K)		Uranium Condensed on Collector (mg)	Weight Loss (mg)	Rate of Weight Loss (mg/cm ² /sec × 10 ⁴)
			Inside T. C.	Outside T. C.			
1	2058	2	1273	1248	0.229	4.4	2.13
2	2053	2	918	1108	0.239	3.3	1.84
3	2063	2	728	1143	0.610	7.4	3.58
4	2063	2	No Collector	No Collector	-----	6.4	3.52

*Using an emitter of UC, a collector of platinum-plated Monel, an interelectrode spacing of 20 mils, a total surface area of 2.875 cm², and an area of surface facing the collector of 0.5687 cm².

Fig. 5--Collector surface after physical-redeposition run: (left) run 1--note ring-like deposit due to temperature gradient; (right) run 2--the center of the collector had a heavier deposit after this run than did the center of the collector at left, although the photographic lighting does not make this apparent; note the heavy deposits in the cooler areas

Examination of both the amount of uranium condensed on the collector and the rate of weight loss shows that there is undoubtedly a reduction in the rate of vaporization with the higher collector temperature. Figures 5a and 5b, which show the collector after runs 1 and 2, also illustrate the influence of collector temperature. As discussed above, the collector had a temperature gradient from the center to the periphery. In each of the photos it is observed that the central region contains less condensate than do cooler regions of the collector, resulting in ring-like deposits. It is thought that most of the condensate removed from the collector was deposited in these cooler regions.

One would expect that the effect of the collector temperature upon the rate of weight loss from the surface facing the collector could be calculated by the following formula based upon a mass balance:

$$\dot{W}_L(A_L)t + \dot{W}_{PR}(A_{TS})t = \Delta W,$$

where $\dot{W}_L$ = the rate of weight loss under Langmuir free-evaporation conditions, in mg/cm²/sec;

$\dot{W}_{PR}$ = the rate of weight loss under the conditions of physical redeposition;

A_L = the surface area of the portions of the emitter which do not face the collector, in cm²;

A_{TS} = the area of the top surface, in cm²;

t = the duration of the run, in sec;

ΔW = the amount of weight lost during the run, in mg.

Applying this formula to run 1 (using the data in Table 1), with the value of $\dot{W}_L$ having been obtained from run 4, the value of $\dot{W}_{PR}$ would have to be negative. This is unrealistic, however, and it was this fact which indicated that the collector's being larger than the emitter was influencing vaporization from the sides of the specimen in addition to vaporization from the top surface. This would reduce the effective value of A_L and make the mass balance correct. The correction to be applied is not known and quantitative results cannot be obtained. Qualitatively, however, it is possible to observe that since only a small fraction of the surface is actually influenced by the collector, then any improvement realized in the rate of weight loss would be indicative of much larger effects if the entire emitter surface were surrounded by the hot collector.

Steps being taken to modify the experimental arrangement to permit quantitative analysis of results are as follows:

1. The size of the collector tip is being reduced to the diameter of the carbide pellet.

2. The reduced section will extend for at least one inch from the tip. Above this reduced section an enlarged region will be used to permit easier access for the gas coolant tubing.
3. The tip of the thermocouple on the inside of the collector will be heliarc-welded into a well extending to a distance of 0.030 in. from the collector surface. Welding the thermocouple into the hole will prevent erroneously low temperature readings due to gas coolant flow.

IV. THERMODYNAMIC CONSIDERATIONS

In order for chemical transport processes to carry material vaporized from the emitter from the cooler collector region back to the emitter surface and redeposit it there, certain conditions must be established:

1. Reactions between the transport media and the species to be transported must take place in the cooler collector region to form volatile species; and these volatile species must then dissociate at the hotter emitter surface. This means that ΔF for the reaction must be negative at the collector temperature and must become increasingly positive with increasing temperature.
2. The concentration of reacting species must be sufficiently great to allow the reactions to proceed at a useful rate.

If the transport process is proved to be feasible on the basis of these restrictions, the following considerations become important: (a) whether the deposits are uniform, (b) whether the total pressure in the system would cause excessive electron scattering in a plasma diode, (c) whether sufficient cesium ions are present to overcome space-charge limitations, and (d) whether the chemical species present adversely alter the work functions and other surface characteristics of the diode components.

Thermodynamic calculations have been made to determine whether condition (1) above is adhered to in the case where HCl is added to transport uranium and hydrogen is present to transport carbon. These data are summarized in Table 2. Since one does not know whether the reaction will take place while the uranium and carbon are still in the vapor state or whether the reaction will not take place until after they have condensed, calculations were made for reactions occurring with each possible state. The calculations also included the two possibilities that (1) HCl does not dissociate before reaction and (2) it does dissociate and the reaction takes place between chlorine ions and uranium.

All of the reactions listed in Table 2, with the exception of the last one presented, meet the first condition stated; i. e., they are negative in the temperature region of the anode and become increasingly more positive as the temperature is increased.

To further establish the feasibility of these reactions it was necessary to proceed to condition (2) above; i. e., sufficient concentrations of the

Table 2
THERMODYNAMIC CALCULATIONS FOR UC TRANSPORT
BY CHLORINE AND HYDROGEN

Reaction	ΔF° (cal/mol)		
	At 500°K	At 1000°K	At 2000°K
$3\text{Cl(g)} + \text{U(g)} \rightarrow \text{UCl}_3\text{(g)}$	-312, 000	-272, 000	-183, 000
$3\text{Cl(g)} + \text{U(s)} \rightarrow \text{UCl}_3\text{(g)}$	-205, 000	-181, 000	-120, 000
$6\text{HCl(g)} + 2\text{U(g)} \rightarrow 2\text{UCl}_3\text{(g)}$ $\quad\quad\quad + 3\text{H}_2\text{(g)}$	-350, 000	-306, 000	-206, 000
$6\text{HCl(g)} + 2\text{U(s)} \rightarrow 2\text{UCl}_3\text{(g)}$ $\quad\quad\quad + 3\text{H}_2\text{(g)}$	-136, 000	-125, 000	-81, 300
$\text{C(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_4\text{(g)}$	-168, 000	-137, 000	-72, 700
$\text{C(s)} + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_4\text{(g)}$	-7, 830	+4, 620	+31, 300
$2\text{C(g)} + \text{H}_2\text{(g)} \rightarrow \text{C}_2\text{H}_2\text{(g)}$	-274, 000	-243, 000	-179, 000
$2\text{C(s)} + \text{H}_2\text{(g)} \rightarrow \text{C}_2\text{H}_2\text{(g)}$	+47, 200	+40, 600	+28, 600

reacting species must be present to allow the reactions to proceed at a useful rate. Thermodynamic calculations were performed and data for the dissociation of gaseous hydrogen halides are presented in Table 3. The reaction considered is

where X = Cl, F, Br, or I. Initial consideration was given to the equation

However, data presented in Table 4 illustrate that $\text{H}_2\text{(g)}$ is not dissociated into the monoatomic species to any significant extent at temperatures below 2500°K. Therefore, Eq. (1) is the proper equation to be employed. Table 2 in Ref. 1 had already considered the dissociation of halogen molecules.

Analysis of the data in Table 3 shows that except for HF, all of the hydrogen halides show significant dissociation over the temperature and pressure range considered. This should favor the redeposition of metal or carbide on the cathode surface. However, even if HCl did not dissociate appreciably in the collector temperature range, Table 2 shows that the transport could still proceed by the reaction

Table 3
DISSOCIATION OF THE HYDROGEN HALIDES*

T (°K)	P (atm)	HF		HCl		HBr		HI	
		K	$\alpha^\dagger$	K	α	K	α	K	α
1000	1.3×10^{-2}	2.2×10^{-31}	3.2×10^{-10}	4.7×10^{-18}	9.0×10^{-7}	1.5×10^{-11}	1.3×10^{-3}	3.6×10^{-10}	3.8×10^{-3}
1500		4.6×10^{-19}	4.1×10^{-6}	2.1×10^{-10}	3.2×10^{-3}	3.2×10^{-6}	7.9×10^{-2}	2.1×10^{-5}	1.5×10^{-1}
2000		7.4×10^{-13}	4.9×10^{-4}	1.5×10^{-6}	6.1×10^{-2}	1.6×10^{-3}	6.3×10^{-1}	5.1×10^{-3}	5.7×10^{-1}
2500		3.8×10^{-9}	8.4×10^{-3}	5.0×10^{-4}	4.3×10^{-1}	6.6×10^{-2}	1	1.4×10^{-1}	1
1000	1.3×10^{-3}	2.2×10^{-31}	7.0×10^{-10}	4.7×10^{-18}	1.9×10^{-5}	1.5×10^{-11}	2.8×10^{-3}	3.6×10^{-10}	8.1×10^{-3}
1500		4.6×10^{-19}	8.9×10^{-6}	2.1×10^{-10}	6.9×10^{-3}	3.2×10^{-6}	1.7×10^{-1}	2.1×10^{-5}	3.2×10^{-1}
2000		7.4×10^{-13}	1.0×10^{-3}	1.5×10^{-6}	1.3×10^{-1}	1.6×10^{-3}	1	5.1×10^{-3}	1
2500		3.8×10^{-9}	1.8×10^{-2}	5.0×10^{-4}	9.2×10^{-1}	6.6×10^{-2}	1	1.4×10^{-1}	1
1000	1.3×10^{-4}	2.2×10^{-31}	1.5×10^{-9}	4.7×10^{-18}	4.2×10^{-5}	1.5×10^{-11}	6.1×10^{-3}	3.6×10^{-10}	1.8×10^{-2}
1500		4.6×10^{-19}	1.9×10^{-5}	2.1×10^{-10}	1.5×10^{-2}	3.2×10^{-6}	3.7×10^{-1}	2.1×10^{-5}	4.8×10^{-1}
2000		7.4×10^{-13}	2.3×10^{-3}	1.5×10^{-6}	2.8×10^{-1}	1.6×10^{-3}	1	5.1×10^{-3}	1
2500		3.8×10^{-9}	3.9×10^{-2}	5.0×10^{-4}	1	6.6×10^{-2}	1	1.4×10^{-1}	1

* For the reaction $2\text{HX(g)} = \text{H}_2\text{(g)} + 2\text{X(g)}$.

† α = fraction dissociated.

On the basis of these thermodynamic considerations a mixture of HCl + H₂ appears to be a suitable transport medium, and this mixture will be the first one studied.

Table 4
DISSOCIATION DATA FOR HYDROGEN*

Pressure (atm)	Temp. (°K)	K	$\alpha^\dagger$
1.3×10^{-2}	1000	5.11×10^{-18}	9.9×10^{-9}
1.3×10^{-2}	1500	3.06×10^{-10}	7.7×10^{-5}
1.3×10^{-2}	2000	2.62×10^{-6}	7.1×10^{-3}
1.3×10^{-2}	2500	6.25×10^{-4}	1.1×10^{-1}
1.3×10^{-3}	1000	5.11×10^{-18}	3.1×10^{-8}
1.3×10^{-3}	1500	3.06×10^{-10}	2.4×10^{-4}
1.3×10^{-3}	2000	2.62×10^{-6}	2.2×10^{-2}
1.3×10^{-3}	2500	6.25×10^{-4}	3.3×10^{-1}
1.3×10^{-4}	1000	5.11×10^{-18}	9.9×10^{-8}
1.3×10^{-4}	1500	3.06×10^{-10}	7.7×10^{-4}
1.3×10^{-4}	2000	2.62×10^{-6}	7.1×10^{-2}
1.3×10^{-4}	2500	6.25×10^{-4}	7.4×10^{-1}

* For the reaction $\text{H}_2(\text{g}) = 2\text{H}(\text{g})$.

$^\dagger \alpha$ = fraction dissociated.

V. FUTURE PROGRAM

PHYSICAL REDEPOSITION

Equipment modifications discussed above will be completed. Studies designed to obtain quantitative data will be prosecuted.

CHEMICAL REDEPOSITION

Preliminary investigations will be started with the experimental equipment just completed. Initial chemical additives will be a mixture of H_2 and HCl , and the emitter material will be UC .

Concurrently, the cell for emission-transport studies will be completed by the electrophoretic deposition of UC on the tungsten filaments. Initial studies will use a transport medium of $Cs + CsF$. The cesium is present to determine if enough cesium ions will be generated to provide space-charge neutralization.

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