UCRL 15948

S/c 8919905

Annual Report to Lawrence Livermore Laboratories

NOV 13 1987

on

THE THERMOPHYSICS OF ELECTRON BEAM EVAPORATIVE SOURCES

under

Contract No. 8919905

for the period 21 April 1986 to 20 April 1987

Prepared by

Professor S. A. Self, Principal Investigator

June 1987

HIGH TEMPERATURE GASDYNAMICS LABORATORY
Mechanical Engineering Department
Stanford University

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract number W-7405-ENG-48.

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

UCRL--15948

DE88 002451

Doc ID: P 5:35

**Annual Report to Lawrence Livermore Laboratories
on**

THE THERMOPHYSICS OF ELECTRON BEAM EVAPORATIVE SOURCES

under

Contract No. 8919905

for the period 21 April 1986 to 20 April 1987

Prepared by

Professor S. A. Self, Principal Investigator

June 1987

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

1.0 INTRODUCTION

In the original proposal dated January 1986, a comprehensive experimental study of the characteristics of an electron beam evaporative source was proposed. It involved the development of a number of novel diagnostic techniques to determine important parameters affecting the overall performance of the source, especially with regard to energy transfer. A modest theoretical modeling effort was also proposed for comparison with experimental data. The proposed program was scheduled to occupy three years and to constitute the thesis component of a Ph.D. program for Mr. John Sze, an employee of LLL who is enrolled as an honors cooperative student at Stanford. The principal investigator, Professor S. A. Self, is the thesis advisor for Mr. Sze.

2.0 WORK ACCOMPLISHED IN THE FIRST CONTRACT YEAR

As detailed below, much of the work scheduled for the first year has been completed. However, as a result of preliminary measurements of the beam current density profile using an X-ray pinhole camera, the satisfactory functioning of the standard electron gun was called into question.

Following a meeting between Professor Self and several staff at LLL, the E-facility which had been refurbished for the proposed program was reassigned for higher priority experiments. Temporarily, until the E-facility becomes available again, diagnostics development work has been continued using a smaller facility, the vacuum test unit (VTU) which incorporates only a low-voltage gun.

2.1 Hardware and Diagnostics Development

2.1.1 E-Facility:

Several weeks were spent in bringing this facility into operating conditions for high-rate source experiments. This work included refurbishing the HV power supply for the gun, the cooling system, the vacuum system, and the facility instrumentation and control systems.

2.1.1 Faraday Cup Analyzer:

A water-cooled Faraday cup system has been designed and constructed to measure the current density profile of the electron beam at the plane of the melt surface. A circuit was built to sweep the beam across the slits of the Faraday analyzer, by modulating the deflecting magnetic field provided by the Helmholtz coils. The gun control circuit was modified to allow the beam current to be switched rapidly on and off to avoid potential damage to the water-cooled slits.

2.1.3 Secondary Collector:

A secondary electron collector was designed and built to measure the current density - energy distribution of the secondary electrons from the melt surface. The collector is segmented with each segment electrically isolated and water cooled so that both the current and power distributions across the collector plane can be measured.

2.1.4 X-Ray Imaging Detector:

An X-ray imaging detector system was designed and built using a pin-hole and proportional counter which could be scanned laterally so as to determine the profile of the beam current distribution where it impinges on the melt. Preliminary results obtained with this system are discussed below.

2.1.5 Data Acquisition:

A new data acquisition system was developed. It consists of a HP-3852S digital voltmeter, an IBM personal computer together with Labtech Notebook software. The reading speeds of the A/D connector range from 55/sec in the 5.5 digit mode to 1600/sec in the 3.5 digit mode. The system has 160 I/O channels, and the software is suitable for both real-time data acquisition, monitoring and display, as well as post-run data analysis via Lotus 123 Software.

2.1.6 Laser Anemometry:

Feasibility tests of using laser anemometry to measure the melt surface velocity were made at Stanford using a dish of mercury rotating on a phonograph table. There was uncertainty as to whether a clean metal surface would give enough diffusely scattered light to allow measurements to be made. It was found that due to surface impurities there was indeed sufficient scattered light to allow surface velocity measurements to be made. The laser anemometry hardware and ancillary optics and electronics have been duplicated at LLL for use on the E-facility.

2.1.7 Melt Surface Temperature Measurements:

The possibility of using a video camera as a two-color imaging pyrometer to measure the distribution of temperature over the melt surface has been investigated and appears to be feasible. The availability of suitable software to perform the image analysis of surface temperature at LLL has been established.

2.1.8 Beam Profile Measurements by X-Ray Imaging:

Preliminary experiments using X-ray imaging to measure the beam current density profile were made on the SDF gun under standard operating conditions of

Gun Voltage 40kV
Beam Current 0-4A
Beam Radius 19 cm for $B = 35$ Gauss.

It was found that the beam width was about 2.8 cm, much larger than anticipated. Also the X-ray profile indicated a triangular (or sawtooth) current density distribution with peaks at the edges. Moreover, the gun characteristics were rather unstable and sensitive to the exact geometry of the filament and accelerating electrode.

Because the gun performance with regard to both stability and beam width were unsatisfactory for the purpose of the planned studies, further experimental work on the E-facility were discontinued.

At a meeting on December 1, 1986, between the principal investigator and a number of senior scientists/engineers at LLL, the whole question of gun design was discussed. A major question that emerged from this meeting concerned the problem of bombardment of the gun filament by positive ions generated by the beam, and ducted back by the static potential distribution created by the beam-generated plasma. Such bombardment makes it difficult to control the filament temperature and emission, as well as contributing to filament erosion, sparking, and shortened filament life.

Following this meeting, a decision was made at LLL to institute a high-priority program which required the use of the E-facility. Consequently, work under this program was transferred to a smaller facility, the vacuum test unit (VTU) which, while not suitable for the planned experimental program on high-rate evaporation, allows diagnostics development to continue independently.

2.1.9 Recent Diagnostics Development:

Following a certain investment of time and effort to put the VTU facility into working order, development of diagnostic techniques for measuring the melt surface temperature and velocity have continued. Because of the much lower beam power available in the VTU, such experimental work will have to use a melt of aluminum.

3.0 CONTINUATION OF WORK

In May 1987 a preliminary copy of a proposal for continuation of this research was submitted to LLL for discussion. Because of a staff reorganization within the Laser Isotope Separation Program at LLL, no action has yet been taken on the renewal proposal.