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UCRL- 93032
PREPRINT

Received by OSTI

APR 21 1987

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This paper was prepared for submittal to
IMOG Joining Subgroup Meeting
Los Alamos National Laboratory
Los Alamos, NM
April 2-4, 1985

Lawrence Livermore National Laboratory

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LASER WELDING OF A BERYLLIUM/TANTALUM COLLIMATOR

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UCRL--93032

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PURPOSE

The purpose was to fabricate a collimator from 0.001 inch thick beryllium and tantalum foil.

CONCLUSIONS

1. A collimator can be fabricated to meet the requirements of this application.

2. The laser welding process has proven to be an acceptable method for joining the beryllium in a standing edge joint configuration.

3. Because of the tedious fitup requirements, each collimator requires approximately four man hours to fabricate. The yield of acceptable units has been approximately 60%.

BACKGROUND

Nuclear Test Engineering Division requested we fabricate a collimator from beryllium and tantalum foil. The part is shown schematically in Figure 1. The objective was to sandwich a piece of 0.001 inch thick tantalum foil between two pieces of 0.001 inch thick beryllium foil. The beryllium was to be fused along one edge. The gap between the fused beryllium and the tantalum was to be .001 ± 0.001 inches. We also fabricated a second part which had the same detail as the 3 inch unit shown but was 1.5 inches in length. Approximately forty parts have been fabricated to date.

PROCEDURE AND RESULTS

Materials

The beryllium foil was identified as high purity beryllium, 99.8% 1F-1, ingot foil. The foil was 0.001 ± 0.0001 inches. The tantalum was commercially pure and was 0.0012 inches thick. Pure beryllium wire 0.002 inches in diameter was also used.

Weld Joint Preparation

In order to achieve a precise fitup of the weld joint, it was necessary to have clearly sheared edges. Shearing on available equipment resulted in excessive rollover of the edge and inadequate precision on the width of the part. We devised a method of hand shearing the part illustrated in Figure 2. The foil width was cut about 0.040 inches oversize and clamped between two pieces of precision ground tool steel. A shim positioned about 0.020 inches of the oversize above the edge of the tool steel. A carbide tool was used to hand shear the excess flush to the tool steel surface using a scrapping action. The procedure was repeated along the opposite edge this time without a shim. This gave us foil pieces with a clean sheared edge with minimal rollover (0.0001 inches) and of the precise width needed.

Weld Fixturing

The copper weld fixture is shown in Figure 3. The surfaces were precision ground. A 0.001 inch flat bevel was honed along the edge. This acts to reflect the laser energy into the weld area.

Our initial procedure was to fitup the weld joint; then, using tweezers, roll the beryllium over the tantalum so the beryllium foils formed a tight fitting standing edge joint configuration. Because of the very limited ductility of the beryllium foil, this procedure proved difficult. When we were able to achieve a reasonable fitup, the weld all too often showed unfused areas such as is illustrated in Figure 4. We were unable to successfully fabricate any of the 3 inch collimators using this approach.

A second procedure was more successful. P. R. Landon supplied some 0.002 inch diameter beryllium wire which proved to be the key to successful fabrication of this part. The wire was placed between the two beryllium foils and in contact with the tantalum foil. This arrangement is illustrated by Figure 5. With the wire in place, the fitup of the beryllium foil was less critical. Figure 6 shows a transverse cross-section of the welded joint; Figure 7, the weld surface. This technique markedly improved the yield of 3 inch parts from 0% to approximately 60%. The problem of fish eyes or unwetted areas such as seen in Figure 4 remains the principle cause of rejections. Using our current techniques, it requires about four man hours to produce a part.

The laser welding parameters used are shown in Table I. There is nothing unusual about the welding parameters with the possible exception of the pulse width. We ordinarily used a pulse width of 5 - 7 ms for welding applications. Using our normal pulse width, we had difficulty reducing the power input to a low enough level to avoid burnback and excessive penetration. Using a short pulse width of 0.6 ms proved an acceptable way of avoiding the burnback problem.

Gas Tungsten Arc Welding was evaluated as an alternative welding method. We were unable to control the penetration and avoid the undesirable alloying of the tantalum into the beryllium. The weld also showed extensive cracking.

Working with beryllium requires extensive safety precautions to avoid inhaling particulate matter. Our procedures were reviewed and approved by Hazards Control and were carefully adhered to during the processing of parts.

DISCUSSION

The laser, because of its capability of focusing controlled amounts of energy on a very small area, is ideally suited for applications such as this. The keys to successfully producing the part were to carefully prepare the edges of the material, properly fixture the weld joint, and attain a good tight consistent joint fitup. In this case, the addition of the beryllium wire to the joint proved crucial to being able to repeatedly produce a satisfactory part.

AUSPICES

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

Table I LASER WELDING PARAMETERS - Be/Ta COLLIMATOR

Laser Processing - Raytheon SE330

MATERIAL	Be/Ta	JOB NAME	Foil Weldment
THICKNESS	.001"	JOINT TYPE	Standing Lip w/.002" wire insert

SURFACE	Sheared
NETWORK	(pulse width #8 .63 ms
APERTURE	1.5 mm
PULSE RATE	10 Hz
P.F.N.	525
POWER J/W	.085 J
LASER MODE	Clean
PENETRATION	Good
SPOT SIZE	.007"
METALLOGRAPHY NO.	

P.F.N. K.V.	1.30
RESERVE K.V.	.62
LAMP POWER K.W.	1.0
FOCUS	@ V (3.980")
LENS	#1B 100 mm
GAS/PURGE	Argon 30 CFM/.062 nozzle

TRAVEL SPEED

TRAVEL/MIN.	1.2 IPM Tack @ 6 IPM
TRAVEL/PULSE	.002"
TIME/REV.	
POT SETTING	CNC 100%

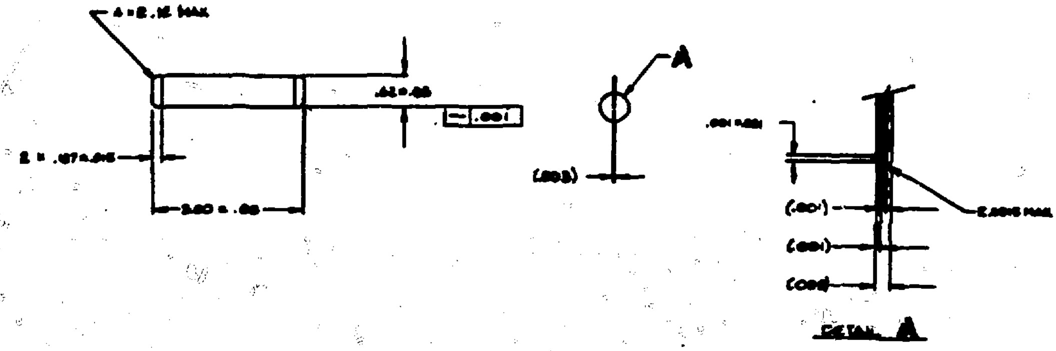

Figure 1 Schematic Diagram of the Be/Ta Collimator

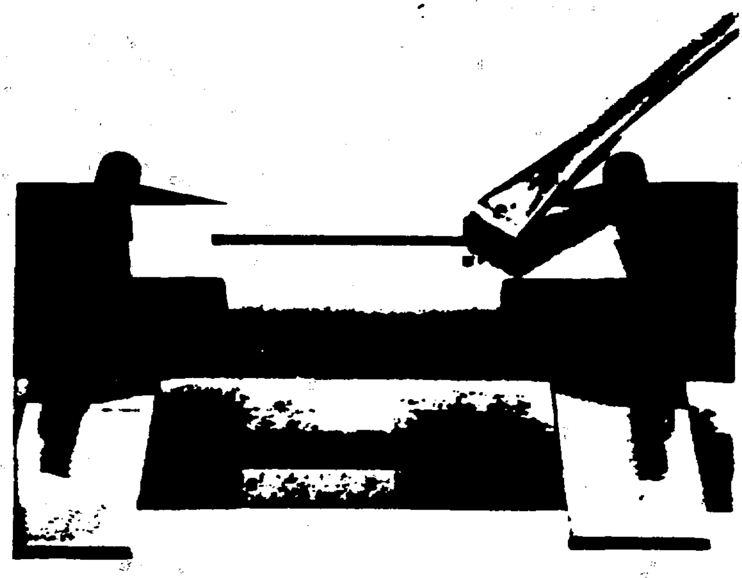

Figure 2 The foil to be sheared is positioned and clamped between two surface ground tool steel squares. The carbide cutting tool is used as a scraper to produce a good clean sheared edge free of rollover.

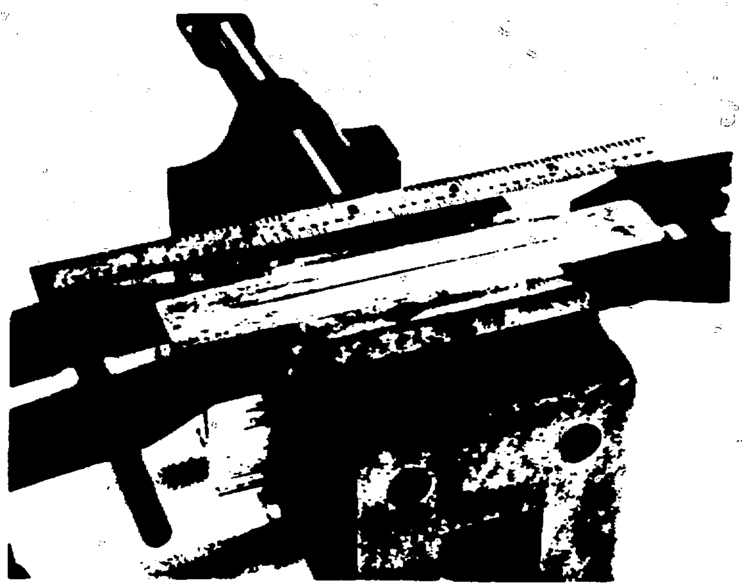

Figure 3 The copper fixture was surface ground. Flat bevels .001 inches wide were ground along the edge to help focus the laser energy into the joint. The beryllium was positioned 0.003 inches above the copper surface; the tantalum was flush with the surface.

Figure 4 Magnification 497X
Scanning electron microscope picture of an area of lack of wetting. This has been the most prevalent defect.

Figure 5 Magnification 95X and 285X
Scanning electron microscope pictures of the 0.002 inch diameter beryllium wire fitted between the beryllium foil.

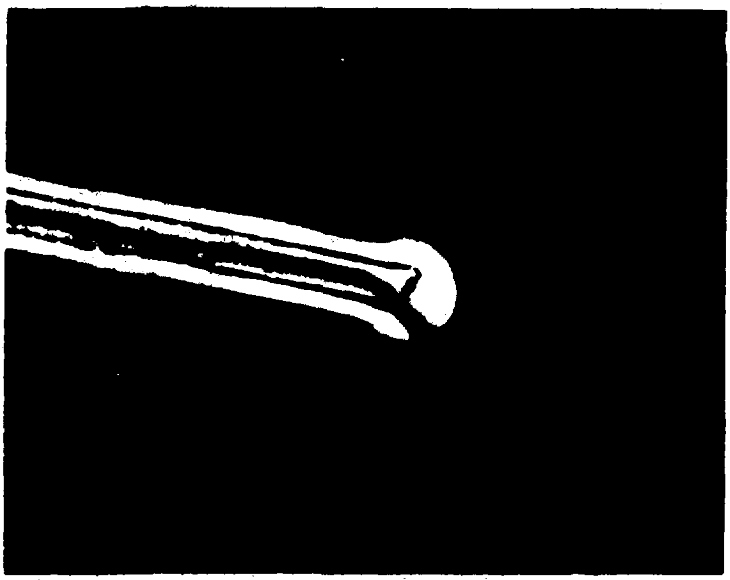

Figure 6 Magnification 200X
Transverse cross-section of weld area

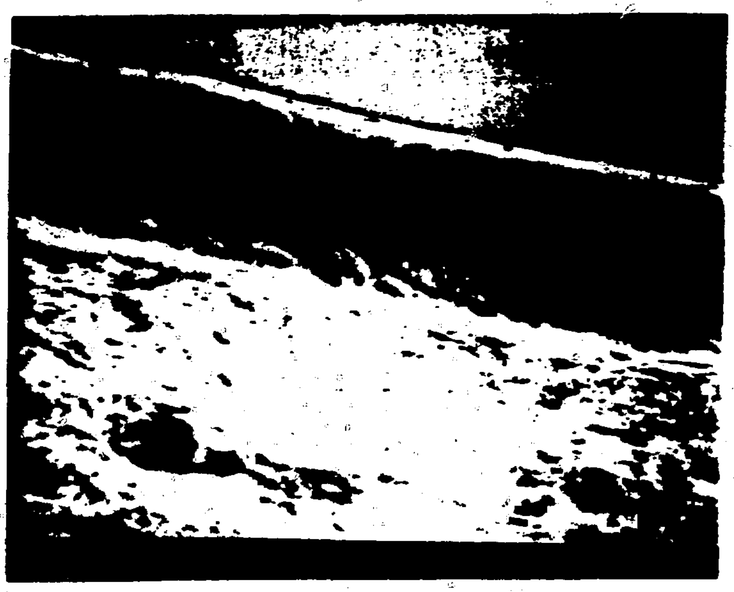

Figure 7 Magnification 267X
Scanning electron microscope picture of the weld surface. No cracking is evident.