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STRAIN GAGING NICKEL-PLATED URANIUM

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STRAIN GAGING NICKEL-PLATED URANIUM

Abstract

This paper presents strain-gage data and techniques used on D-38 test beams that have been electroplated with nickel and gold and

tested at 75 and 400°F. The strain gages provided accurate measurements when bonded to the nickel-plated uranium surface.

Introduction

Bonding strain gages or similar transducer devices to bare uranium presented many problems a few years ago. Bare uranium oxidizes very quickly in air at modest levels of humidity and temperature. If a metallic protective coating is applied over the uranium material, it will suppress uranium oxidation. The rate of oxidation depends on the quality and type of plating job, the humidity level, and the temperature.

Two plating techniques have been helpful in advancing the state of the art in strain gaging uranium, uranium alloys, and plutonium materials:

1. Vapor deposition of aluminum on uranium.¹
  2. Electroplating uranium with nickel.²
- Both plating techniques offer some advantages

and disadvantages; one should decide which process is best for a particular job.

Advantages of Nickel Electroplating

1. Plating can be applied at 75°F.
2. It is less expensive than vapor deposition.
3. Plating can be several mils thick.

Disadvantages of Nickel Electroplating

1. The surface is left quite rough by the plating process.
2. Pinholes can sometimes appear in the plating.

Advantages of Aluminum Vapor Deposition

1. The aluminum surface provides a good, bondable surface for strain gages.
2. The surface is free of pinholes.

A Recent Application

A need developed to strain gage some D-38 parts that could not be subjected to temperatures above 75°F before testing. Sandia Laboratories, Livermore, provided the nickel and gold plating on two D-38 test beams for strain gage evaluation. The complete plating procedure may be found in Ref. 2. Sandia recommended that a thin deposit of gold be applied over the nickel to improve the strain gage bond (see Fig. 1).

TEST BEAM 1 (75°F TEST TEMPERATURE)

Procedures

Four Micro-Measurements, Inc., type WK-06-250BG-350 strain gages* were selected for bonding to a 1- by 10- by 1/8-in. nickel- and gold-plated test beam. Two strain gages were applied to each side of the test beam for measuring tension and compression. The test beam was cleaned with cotton applicators saturated with 190-proof ethyl alcohol, wiped dry with Kleenex tissues and dried with a hair dryer (125 to 150°F air temperature) for approximately 5 min. The strain gages and terminal strips were removed from their packages with tweezers and placed on strips of Scotch tape. Since the strain gages and terminals are cleaned at the factory, no attempt was made to clean them again. Strain gage catalyst was applied to the strain gage backing and plated surface. The plating is very

porous, and it was found that if catalyst was only applied to the strain gage backing, the Eastman 910 adhesive would not set up fast enough. Eastman 910 (specially selected lot) was applied to the plated area, and the strain gage was rolled into place. The tape was removed, and the four strain gages were soldered to the terminal strips, wired up, cleaned with rosin solvent, and then degreased with Freon TF. Mobil 2305 Micro-Crystalline wax was applied over the gage area for protection against humidity and mechanical damage. The test beam was installed in the test fixture, and initial zero balances were measured with an LLL-fabricated switch and a commercial strain indicator (Fig. 2). The test beam was loaded at

Figure 1. Photomicrograph of a gold- and nickel-plated D-38 test beam sectioned after testing at 400°F. Thicknesses: gold = 0.000062 in., nickel = 0.000750 in. Magnification: 1000X.

*Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Atomic Energy Commission to the exclusion of others that may be suitable.

Figure 2. Instrumentation setup for room-temperature testing.

75°F in May 1971 and the following data were measured:

Channel No.	Load (min./in.)
1	+ 840
2	- 740
3	- 730
4	+ 730

Results

After seven months of testing at 75°F, the strain gage creep was less than ± 10 min./in.

TEST BEAM 2 (400°F TEST TEMPERATURE)

Procedures

Four strain gages of the same type were selected for bonding to a 1- by 10- by 1/8-in. nickel- and gold-plated test beam. The test beam was cleaned with cotton applicators saturated with 190-proof ethyl alcohol, wiped dry with Kleenex tissues and dried with a hair dryer for approximately 5 min. The strain gages and terminal strips were removed from their package with tweezers and placed on strips of Teflon tape. The strain gages and terminals were not cleaned with

solvents. Epoxylite 8729 adhesive was selected for bonding the strain gages and terminal strips. Adhesive was applied to the gages and terminals, and clamping pressure of 15 to 30 psi was used for holding the gages in place during curing. The test beam was placed in the curing oven and cycled from 75 to 250°F. After the test beam reached 250°F, the gages were cured for 2 hr. The clamps were then removed and the test beam was cycled from 75 to 400°F and held for 1/2 hr after the test beam temperature reached 400°F.

The four strain gages were soldered to the terminal strips, wired up, cleaned with rosin solvent, and then degreased with Freon TF. Gagekote #1 was applied over the gage area for mechanical protection. The test beam was installed in the test fixture, and initial bridge balance measurements were measured with an LLL-fabricated switch and a commercial strain indicator (Fig. 3). A Chromel-constantan thermocouple was attached to the test fixture to monitor the temperature of the test beam during oven cycling. The test fixture was placed in the oven and cycled from 75 to 400°F. All four strain

Figure 3. Instrumentation setup for high-temperature testing.

gages returned to their initial zero balances within 10 $\mu\text{in./in.}$ The test beam was then loaded at 75°F and the following data were measured:

Channel No.	Load ($\mu\text{in./in.}$)
1	- 975
2	- 980
3	+ 995
4	+ 985

Results

The loaded test beam was cycled from 75 to 400°F, held for 42 min at 400°F, then cooled to 75°F. The following strain gage zero-balance shifts were measured:

Channel No.	Load ($\mu\text{in./in.}$)
1	+ 15
2	+ 20
3	- 5
4	- 5

Conclusions

Electroplating uranium with the nickel-gold process has provided accurate, inexpensive strain gage measurements for both 75 and 400°F tests. All data obtained from the two D-38 test beams appear

similar to data measured from test beams made of aluminum or steel.

Test beam 2, which was tested to 400°F, was machined through the center of the strain gages and a photomicrograph

was taken (Fig. 1). One can observe that the plating is still intact and that no chemical reactions have occurred.

Since uranium will continue in use for the foreseeable future, one must continue

to look for better and more easily applied techniques for preventing surface oxidation. Contamination hazards are also minimized when a protective coating has been applied over the uranium material.

Comments on Adhesives and Cleaners

The adhesives and cleaners used for these tests were selected because they had been tested and determined to be compatible with plated-uranium surfaces.¹

some adhesives and cleaners react violently with plated and unplated uranium surfaces; one must be sure they are compatible and cannot select them at random.

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