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Technological Research on Miniature Dewar Flask Lead Wires for Multiple Element Infrared Detectors

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Abstract: The technology of miniature Dewar flask lead wires for multiple element infrared detectors is the key to manufacturing Dewar flasks. Previous lead wire forms (including metal conducting wires inlaid on cold fingers and lead wires carved on the metallized outer surfaces of cold fingers) each have their own advantages and disadvantages. Based on research of the latter technology, the authors have researched a new kind of lead wire technology which can produce lead wires that are 0.2mm wide, spaced at 0.2mm intervals, and have an impedance of just one ohm (Ω). Vibration and low-temperature environment experiments have produced ideal results.

Key words: Multiple element infrared detector, Dewar flask, Dewar flask electrode lead wire, eutectic material

1. Introduction

The miniature Dewar flask is the critical part of an infrared detector, and Dewar flask lead wire technology is the key to Dewar flask production, especially for Dewar flasks used in multiple element infrared detectors. Because they have many lead wires that are spaced close together, they have a high degree of technical difficulty. At present, there are many people in China and overseas who are involved in research in this field. Reported lead wire forms can be grouped into the following two categories: first is the immersion method, wherein metal conductors are inlaid on a cold finger; and second is the thin film method, wherein the outer surface of a cold finger is metallized and electrode lead wires are then sculpted on it.

The immersion lead wire method consists of inlaying several dozen, or even upwards of a hundred, metal lead wires on an approximately 15mm-diameter glass tube. At present, this is mainly done by hand, and is a rather complex technology. The finished-product rate is determined by the skill level of the operator. This process takes a lot of time and work, is not suited to mass production, and has a rather high cost. The thin film lead wire method consists of using vacuum evaporation or sputtering methods to deposit metal onto the surface of a cold finger, thus making one or many layers of metal film, and then engraving conductors on it. The advantages of this method are simplicity of technology, good repeatability, and suitability to mass production. Its obvious disadvantage is that the force binding the metal film (which is deposited by vacuum evaporation, sputtering, or other methods) to the glass is intermolecular bonding, and in conditions where there is a large change in temperature, the tightness of the bonds decreases. If a laser is used to carve lead wires,

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the metal wires may peel away from the glass.

The new method we have researched consists of plating liquid metal on the outside of a cold finger so that it is tightly bonded there, and then carving electrode lead wires on it. Experiments prove that this method not only performs well, it also overcomes the shortcomings of the two methods mentioned above.

2. Eutectic Mixtures

The first-choice metal for metallization of the cold finger surface is gold, because gold is an excellent conductor of electricity. If melted gold can be bonded to the surface of a cold finger, its bonds will clearly be tighter than those of vacuum-evaporated, sputtered, or otherwise deposited layers. The problem is that the melting point of gold is 1083°C, and the softening temperature of glass is between 500 and 600°C. When ultrafine gold powder is heated to a molten state [along with glass], the glass will become soft and shapeless early on. Thus, it is impossible to bond pure gold powder to a glass surface. If a medium can be added to the gold to produce a binary eutectic mixture, and a eutectic mixture can be produced with the glass at the same time without producing a gold-medium-glass ternary mixture, it is possible to make melted gold powder that contains a certain medium cohere tightly to a glass surface.

The binary eutectic mixture to be chosen must conform to the following requirements:

(1) The amount of medium added cannot obviously lower the eutectic mixture's

conductivity;

(2) The gold-medium-glass eutectic mixture must be stable and not decompose or give off gases when subjected to vacuum or low temperature conditions;

(3) Careful consideration should be given to the melting temperature of the eutectic mixture of gold with the medium.

There are few media that conform to the above-listed requirements. They are limited to several inorganic materials, since no organic materials mixed with metals have these characteristics.

The binary eutectic mixture produced has, roughly, the following three states (as shown in the figure below):

State 1: The primary component of the binary eutectic mixture is gold. Adding a small amount of medium should not affect the electrical conductivity of the binary eutectic mixture.

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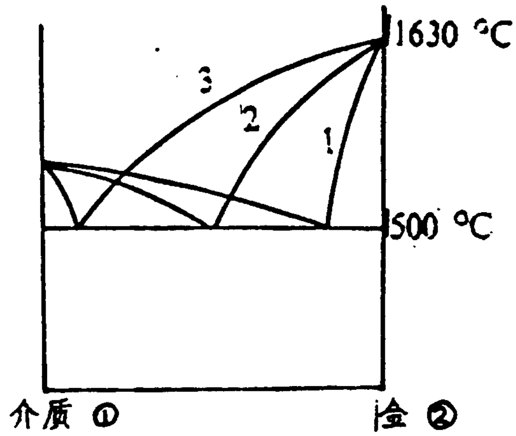
State 2: Gold and medium components are equal. If too much medium is added, it will affect the electrical conductivity of the binary eutectic mixture.

State 3: Medium component is obviously much greater than gold content, and the mixture's electrical conductivity is clearly reduced.



Key: (1). Medium. (2). Gold.

Judging from the above three states, content of added medium directly affects the electrical conductivity of the binary eutectic mixture. Thus, choosing an appropriate proportion is the key to settling on a eutectic mixture.

3. Experiments and Results

By first screening gold-medium binary eutectic mixtures and then carrying out binary eutectic mixture experiments on media and glass, we finally obtained a satisfactory medium.

A certain proportion of medium and ultrafine gold powder were added to a chemically correct solvent, mixed evenly, plated on the outer surface of a glass tube, and then heated. The gold and the medium melted and cohered to the surface of the glass, thus metallizing the glass surface.

During the experiment, a problem was encountered when the metallization caused internal stress on the glass, but the problem was eliminated.

Finally, we successfully used this plating method to completely metallize the outer surface of the cold finger, and could adjust the thickness of the plating. A laser was used to carve electrodes on the metal layer of the outer surface of the cold finger. No layers peeled away from the processed surface; it was complete. The electrodes have very good solderability.

We carved 88 0.2mm-wide gold electrodes on a Φ13mm glass tube, and are fully able to further reduce the spacing between electrodes.

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4. Results and Discussion

It is well known that not only do guidance heads for small infrared missiles require detectors with a high degree of sensitivity, they also have very harsh size limits, and they must pass extremely strict vibration and routine tests.

Certain types of guidance heads researched by this institute have used cohesive-electrode Dewar flasks. During tests and experiments, very strong interference has been discovered in the rotating magnetic fields of the guidance heads. If the infrared detector's static noise is 1, after the gyroscope rotor in the guidance head rotates, its dynamic noise is 100 to 300 times greater. In vibration experiments, resonance takes place at vibrating frequencies between 800 and 1000 Hz, and loss-of-target phenomena occur.

By changing from cohesive electrodes to plated gold electrodes, under acceleration and vibration conditions of 20–2000 Hz and six g's, the detector's noise increase is no greater than 170%, which meets overall requirements for missiles and produces satisfactory results.

Users feel that the gold electrode lead wire plating is bonded tightly, the lead wire method is easy to modify, it won't become loose, and it has strong electric conductivity. It has the following advantages when used to manufacture high-density electrode lead wires:

(1). Many different kinds of electrode lead wires can be manufactured in straight-tube and stepped Dewar flasks, with a high degree of reliability;

(2). Gold electrode lead wires have stable performance in shock, vibration, and high- and low-temperature experiments;

(3). Lead wire width, spacing, and routing methods are flexible;

(4). The technology involved is uncomplicated, the production cycle is short, and [this method] is suited to mass production.

This technology is suitable for use in producing different wave-band material Dewar flasks used in infrared detectors, ranging from single element to multiple element detectors. This technological breakthrough will no doubt have a great significance in the spreading and application of China's infrared detector technology. We sincerely hope to cooperate with others in the same profession and work together to narrow the technological gap with foreign countries.