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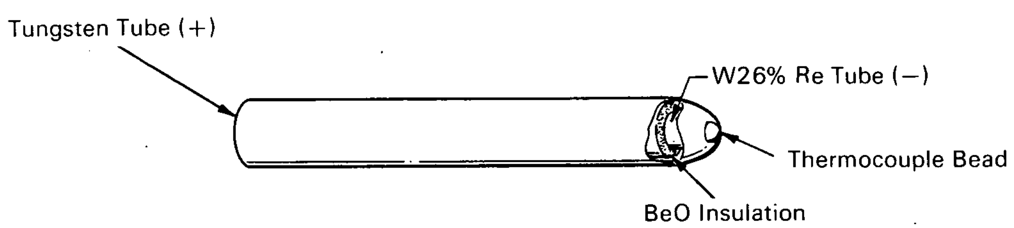
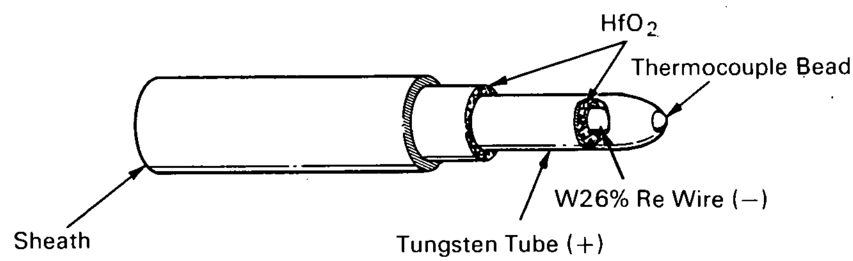
Vapor Deposition Process Provides New Method for Fabricating High Temperature Thermocouples



FIRST TECHNIQUE



SECOND TECHNIQUE

The problem:

Thermocouple temperature measurements in confined spaces present physical problems that interfere with the achievement of a high degree of accuracy. In addition, mechanical problems become substantial where the thermocouple is required to operate over a wide range of temperatures. In conventionally designed two-wire thermocouples having hard-fired insulators and a metal sheath capable of temperatures above 3000°F, approximately 30% of the available space may be used to provide the minimum required mechanical clearances. This requires the use of smaller diameter wires which results in a reduction in temperature measurement accuracy because of insulator shunting at high temperatures.

The solution:

Fabrication techniques which bind all components so that differential thermal expansion and contraction do not result in mechanical slippage and localized stress concentrations. The space required for installation is greatly reduced or given the same available space; larger thermoelements and thicker insulation can be used to improve temperature measurement accuracy.

How it's done:

Two separate deposition techniques are used, varying materials as required, to form coaxial-type thermocouples with the conducting metal components insulated from each other by vapor-deposited refractory oxides.

(continued overleaf)

The first technique uses a vapor-deposited W 26% Re tube on which a layer of BeO is deposited, followed by a vapor-deposited layer of tungsten over the BeO to form two concentric tubular thermoelements.

The second technique uses a tungsten or tungsten–rhenium alloy thermocouple wire, followed by deposits of (1) a layer of HfO_2 insulation, (2) a tubular thermoelement of opposite polarity over the HfO_2, (3) another layer of HfO_2 on top of the tubular thermoelement, and, finally (4) a protective sheath over all. The resultant thermocouple is a high density coaxial design complete with outer electrical insulation and a protective sheath.

The hot junction is formed during the vapor deposition process by allowing one end to have deposited metal between the wire and element. Thermocouple fabrication by this method results in a tightly packed material which is resistant to slippage and resultant stress concentrations during heatup and cooldown. The HfO_2 was selected for its high temperature capabilities and its relative freedom from toxicity problems.

Test results have indicated duration times of about two hours at temperatures above 3500°F. Based upon achieved results it appears that these types of thermocouples can be made to withstand a temperature of 4600°R for one hour.

Notes:

1. A number of design variations are possible for both techniques, yielding tradeoffs between mechanical complexity, performance, and monitoring flexibility.
2. Although several practical laboratory versions of these thermocouples have been constructed, production versions have not been fabricated.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   AEC–NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C. 20545
   Reference: B67-10616

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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