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BIMETAL CAPABLE OF DEFORMATION

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ABSTRACT OF THE DISCLOSURE

A bimetal is disclosed that consists essentially of a first metallic element that undergoes two phase changes at two preselected temperatures. The first element is metallurgically bonded to a second metallic element that does not undergo phase changes under the operating temperatures and has a coefficient of thermal expansion which approximately matches the first element through the range of the preselected temperatures. The bimetal is deformed a predetermined amount by subjecting the bimetal to one of the transformation temperatures. After deformation the bimetal remains in the deformed state without an appreciable change until the bimetal reaches the other phase change temperature.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to bimetals. More particularly it relates to bimetallic materials that are capable of being deformed a predetermined amount upon heating or cooling.

Conventional bimetals are used to yield a deflection of the composite with a change in temperature by utilizing the differences in the coefficients of thermal expansion of two alloys which are metallurgically bonded along a common interface. As can be appreciated these bimetallic materials deflect throughout a given temperature range. Therefore, such bimetallic elements are useful in indicating the temperature over a range of temperatures.

In certain applications, however, it would be beneficial to have a material which could be placed in a location, subjected to a particular temperature upon which the material would deflect a desired amount and thereafter retain the same amount of deflection until subjected to a second particular temperature. A material yielding these properties would be an advancement in the art.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide a bimetallic material capable of controlled deformation.

It is a further object of this invention to provide a bimetallic material having a constant deformation over a predetermined temperature range.

It is an additional object of this invention to provide a bimetallic material which can be cooled or heated to reach a first preselected temperature thereby producing a controlled deformation which deformation remains constant until a second preselected temperature is reached at which the material is converted to its original shape.

These and other objects are achieved in one aspect of this invention by providing a bimetal material consisting essentially of a first metallic element which undergoes a first phase change at a first preselected temperature and a second phase change at a second preselected temperature that is substantially different than the first preselected temperature. A second metallic element which is metallurgically bonded to the first element along a common interface is single phase throughout a temperature range which overlaps and is substantially broader than the range between the first preselected temperature and the second

preselected temperature. The coefficient of the thermal expansion of the second element is substantially the same as that of the first element between the first preselected temperature and the second preselected temperature.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the above description of some of the aspects of the invention.

The bimetallic materials of this invention employ as a first element a metal which undergoes a phase change at a first preselected temperature, referred to herein as T_1, at which temperature the metal undergoes a pronounced change in volume. This phase will remain until the temperature reaches a second preselected temperature, refererd to herein as T_2, at which the metal is transformed to the original phase. The first element is metallurgically bonded to a second metallic element having a single phase over a temperature range which overlaps and is broader than the range between T_1 and T_2. The second element has substantially the same coefficient of thermal expansion as the first element between T_1 and T_2. By a phase change, as used herein, it is meant that the original phase is at least partially replaced by a new phase. The bimetallic material of this invention can be fabricated by different methods to yield a bimetallic material which will function in numerous ways.

For example, if the first and second metallic elements are bonded together and are cooled to T_1 while the first element is in the austenite phase an appreciable conversion to the martensite phase will occur with an increase in volume. Since the second element does not transform at T_1 the bimetallic element deforms by an amount determined by the new volume of the first element. The second element is selected to have a coefficient of thermal expansion substantially the same as the first element in the martensite phase, therefore the material does not additionally deform while the temperature is being raised, until T_2 is reached where the first element transforms back to austenite. The bimetallic element at T_2 regains its original shape. Upon further elevation of temperature above T_2, the bimetallic element will operate in a conventional manner depending upon the coefficients of thermal expansion of the two elements and will continue to function in its original shape as a conventional bimetal until cooled to T_1.

To provide a bimetallic material of this invention that undergoes the deformation upon being heated to T_1, the coefficient of expansion of the second element is matched with that of the first element after the phase change occurs upon heating to T_1. In this instance T_1 is not numerically equal to T_1 in the previous described embodiment but merely refers to the temperature where the first element undergoes a first phase change. The numerical values will depend upon the particular alloy. In this embodiment the first element is transformed upon reaching T_1 from martensite to austenite and the deformation of the bimetallic material of this invention occurs. The deformation will remain relatively constant until the temperature of the material reaches T_2 at which time the first element is appreciably transformed to a martensite phase and the deformation is eliminated.

The bimetallic materials of this invention can be used in a variety of shapes. For example, often in assembly of various devices space limitations are severe and it may be desired to fasten two or more elements together using bolts and the like. The materials of this invention enable the assembly of the various elements together loosely and if the materials of this invention herein are used as con-

ventional washers along with nuts and bolts, then upon a simple heating or cooling to T_1 of the assembled device, the material of this invention will deform and remove the looseness and act as a lock washer. The device will become securely fastened and remain in this state. If it is desired to disassemble the device, all that is required is to reverse the process and either raise or lower the temperature to T_2 depending upon which was done to cause the original deformation. The material of this invention will then assume its original shape and the nut can be easily removed from the bolt. Numerous geometric shapes can be utilized, for example, springs, washers, rivets, fasteners, etc. Additionally, the elements of this invention can be used as thermosensitive electrical switches since they will deform upon reaching a particular temperature.

A metal particularly suited for a first element is an iron-nickel alloy consisting essentially of from about 31 to 33% by weight nickel, balance iron. One phase change temperature of that alloy is near the temperature of Dry Ice (—78.5° C.). At that temperature and below the alloy undergoes an appreciable transformation from the austenite to martensite phase. Upon heating from about 300 to 400° C., a transformation of the alloy from martensite to austenite occurs. A material which can be used as a second with the foregoing first element is an alloy consisting essentially of about 50% by weight nickel, balance iron which is single phase throughout the temperature ranges used. The bimetallic material fabricated from the foregoing elements would deform upon being cooled to —78.5° C. or below and remain deformed until a temperature of about 300° C. is reached. Another suitable alloy for a first element to be used in conjunction with the foregoing second element is an alloy consisting essentially of about 28% by weight nickel, about 17% by weight cobalt selected minors balance iron alloy. A bimetallic material so constructed would deform at temperatures below about —20° C. and remain deformed until a temperature of about 600° C. is reached.

If a bimetallic material is desired which deforms upon heating to T_1 and remains deformed until cooled to T_2 it can be fabricated by using an alloy consisting essentially of from about 35% to 38% by weight nickel, about 0 to 3% by weight of manganese or chromium, balance iron as the second element and the beforementioned 33% nickel-iron alloy as the first element when the first element is originally in the martensite phase.

In most instances, it will be desired to use a first element having one phase change temperature below about —20° C. and another phase change temperature, above about 200° C. The first and second elements should have substantially the same coefficients of thermal expansion during the time the material is deformed and between T_1 and T_2, that is, the differences in the average coefficients of expansion between the two elements when in the deformed state and between T_1 and T_2 should not exceed about 5 p.p.m./° C.

While there has been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A bimetallic material consisting essentially of a first metallic element which undergoes a first phase change at a first preselected temperature and second phase change at a second preselected temperature, said first element being metallurgically bonded along a common interface to a second metallic element being single phase throughout an operating temperature range which overlaps and is broader than the temperature range between said first and second temperatures and having substantially the same coefficient of thermal expansion as said first element between said first and second preselected temperatures after said first element has reached said first preselected temperature.

2. A bimetallic material according to claim **1** wherein said first element converts from the austenitic phase to martensitic phase below about —20° C. remains in the martensitic phase to at least about 200° C.

3. A bimetallic material according to claim **2** wherein said second element has a coefficient of expansion substantially the same as the coefficient of expansion of the first element when said first element is in the austenite phase after reaching said first preselected temperature.

4. A bimetallic material according to claim **2** wherein said second element has a coefficient of expansion substantially the same as the coefficient of expansion of the first element when said first element is in the martensite phase after reaching said first preselected temperature.

5. A bimetallic material according to claim **4** wherein said first element is an alloy consisting essentially of about 28% by weight nickel, about 17% by weight cobalt, balance iron.

6. A bimetallic material according to claim **4** wherein said first element is an alloy consisting essentially of from about 31 to 33% by weight nickel, and balance iron.

7. A bimetallic material according to claim **5** wherein said second element is an alloy consisting essentially of about 50% by weight nickel and balance iron.

8. A bimetallic material according to claim **6** wherein said second element is an alloy consisting essentially of about 50% nickel and balance iron.

9. A bimetallic material according to claim **3** wherein said first element is an alloy consisting essentially of from about 31 to 33% by weight nickel and balance iron.

10. A bimetallic material according to claim **9** wherein said second element is an alloy consisting essentially of from about 35 to about 38% by weight nickel, from about 0 to about 3% by weight of an element selected from manganese and chromium and balance iron.

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