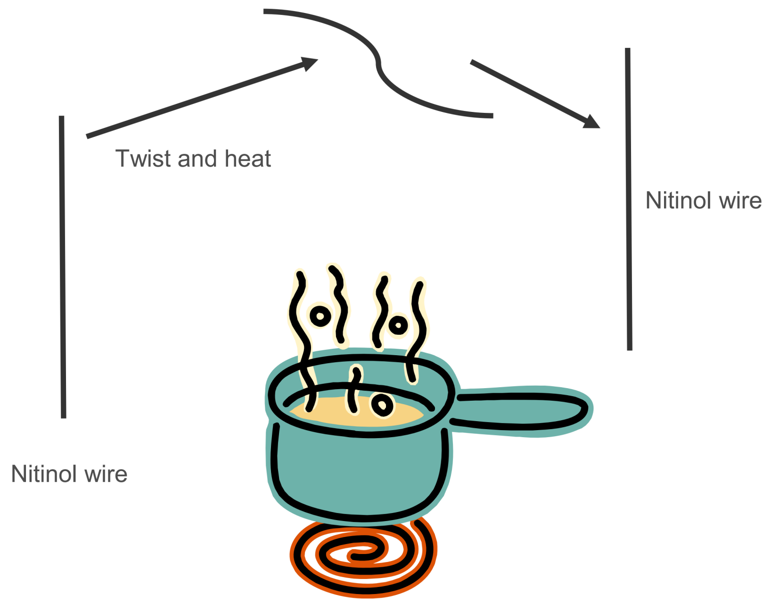

Developed by Howard Nanoscale Science and Engineering Facility and National, Nanotechnology Infrastructure Network (NNIN),

NNIN National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

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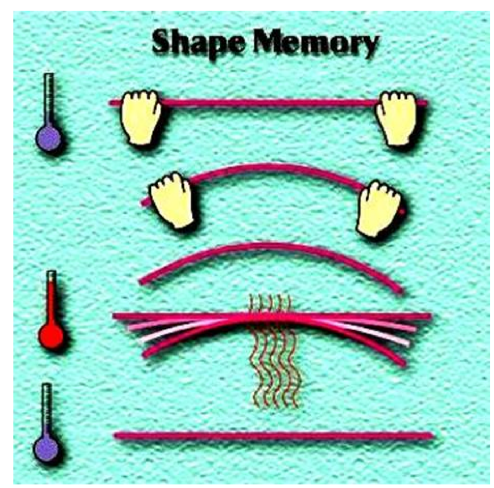
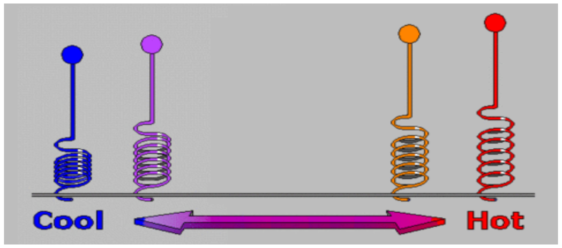
Shape Memory Alloys

"Materials that Remember"





Introduction

All engineers and scientists are involved with materials on a daily basis. We manufacture and process materials, design and construct new structures using materials, select materials, analyze failures of materials, or simply hope the materials we are using perform adequately. To coin a phrase, "technology is the engine that drives to world economy and materials are the fuel." The intent of this short handout is to provide some information on a new class of materials which have some artificial intelligence.

These smart materials can really think and do all kinds of things. Shape memory alloy (SMA) wires are an example of a smart material. Dip it in cold water, and twist it, bend it, and reshape it. Then place it in hot water - BANG - it straightens with amazing force and speed (twist it, bend it – BANG- it's straight again!).

In 1932, Swedish researcher Ame Olander observed the shape and recovery ability of a gold-cadmium alloy (Au-Cd) and noted that it actually created motion. (A. Olander. "Ztsch. Krist." 1932.). In 1950, L.C. Chang and TA. Read at Columbia University observed this unusual motion at the microscopic level by using x-rays to note the changes in crystal structure of Au-Cd. (L.C. Chang and TA. Read. "The Gold-Cadmium Beta Phase" Trans. AIME. Vol. 191, p. 47 1951). As a result of Chang and Read other such alloys were discovered including indium-titanium. In 1963, W.J. Buehler and co-workers at the US Naval Ordinance Laboratory (NOL) observed the shape memory effect in a nickel and titanium alloy, today known as nitinol ("Night in All"). Other studies followed and researchers found

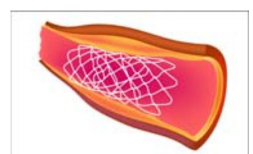
Nickel titanium and copper-zinc-aluminum became the materials of choice because of their low cost, strength, large-shape changing abilities, and ease of fabrication.

Shape memory alloys (SMA) belong to a class of materials which display the shape memory effect (SME). These alloys possess the ability to radically change crystal structure or phase at a distinct temperature. Imagine the ability to change water into ice, or steam into water instantaneously. Unlike most metals, if the alloy is below the "transition temperature," it can be stretched and transformed without permanent damage.

After the alloy has been reshaped or stretched, if it is heated above the transition temperature, the alloy "recovers" and returns to the un-stretched shape. The alloy can remember its original shape – it's smart. The shape of the SMA can be set and reset many times. Simply clamp the wire or SMA into the desired shape, and heat it above 500-550ºC for 10 to 60 minutes, the SMA will take the new shape once quenched into a water bath. SMAs intended for use at room temperatures typically have transition temperatures near 70ºC.

In the past twenty years, SMAs (shape memory alloys) have been incorporated into a variety of products. Coffee makers, eyeglass frames, guide wires for arthroscopic surgery, staples for attaching broken bone fragments, and a mechanical coupler are just some applications. These products can display lifetimes in the range of

Applications


Stents


Coffee mak-


Braces


Eyewear


Surgical devices