Shape Memory Alloys

The term alloy describes a solid structure that is composed of two or more elements. Shape memory alloys (SMAs) are unique alloys in that they can "remember" an original shape after being deformed. Nitinol is an example of a shape memory alloy. Nitinol is a combination of nickel and titanium and was developed by the Naval Ordnance Lab in 1962[1] although some scientists will say that it was actually discovered back in the 1930s. Other types of SMAs include titanium-palladium-nickel, nickel-titanium-copper, gold-cadmium, iron-zinc-copper-aluminium, titanium-niobium-aluminium, uranium-niobium, hafnium-titanium-nickel, iron-manganese-silicon, nickel-titanium, nickel-iron-zinc-aluminium, copper-aluminium-iron, titanium-niobium, zirconium-copper-zinc and nickel-zirconium-titanium.[2]

SMAs have 2 interesting characteristics. They are pseudo-elastic and have a shape memory.[3] The fact that they can undergo a solid to solid phase transition (or molecular rearrangement) gives rise to these characteristics. SMAs can exist in 2 stable forms; the Austenite and Martensite form. At low temperatures, SMAs exist in the Martensite form which is the soft and easily deformable phase. In the undeformed state, the molecules are twinned as shown in the figure below. Upon deformation, the molecules are no longer twinned but are now in the deformed Martensite stage. To return the SMA to the undeformed state a temperature change is required which may be as low as 10°C. Austenite is the stronger phase and this phase occurs at higher temperatures. The molecules are in a cubic arrangement at this phase. This is also the phase where the shape memory can be set. The SMA is heated to approximately 500°C and shaped into the desired shape. Rapid cooling of the SMA causes a change from the Austenite phase to the Martensite phase.

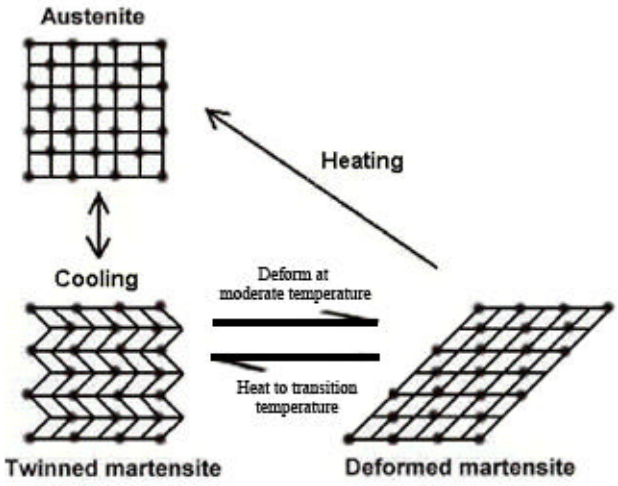

Figure 1: Forms of Shape Memory Alloys
Adapted from Oulu University - http://herkules.oulu.fi/isbn9514252217/html/x317.html

Applications for SMAs

SMAs are used both for their shape memory effects as well as their pseudo-elasticity. They are currently used in coffeepots, the space shuttle, thermostats, vascular stents and hydraulic fittings in airplanes for their shape memory effects. They are also used in eyeglass frames, bra underwires, medical tools, cellular phone antennae and orthodontic arches for their pseudo-elastic effects.[3]

SMAs are used in medical stents by forming it into a fine mesh and shaping it into a cylinder. After cooling the stent, it is inserted into collapsed blood vessels where the heat of the blood causes the stent to expand and open the blood vessel as shown in figure 2.[5] As well, Nitinol wire is used to break up blood clots by creating a fan like structure that is collapsed and inserted into blood vessels. Once opened in the blood vessels, the wire formation helps break up blood clots as shown in figure 3.[6]

http://www.designinsite.dk/htmsider/kb0052.htm

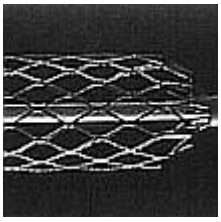

Figure 2: Nitinol mesh used as stent to open collapsed blood vessels.

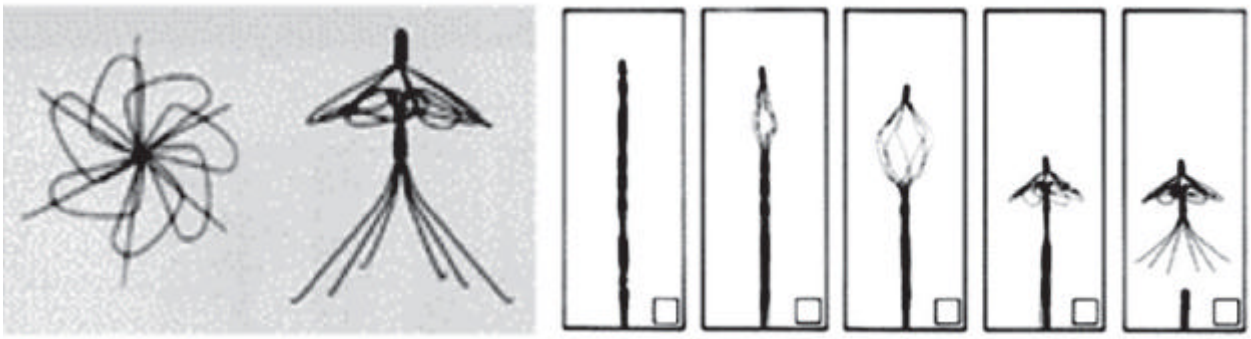

Figure 3. Simon filter. *A*, Filter in the recovery form. *B*, Filter release. Taken from Ref. 26 (http://www.nmtmedical.com).

Nitinol wire may be purchased from various sources. ImagesSI is one American supplier who also sells Nitinol heat engines, biometal robot arms, Nitinol compression springs and other SMA-related items(http://www.imagesco.com/).

References:

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