Copper and Nitinol Shape Memory Alloy Fibers for Development of Smart Fabrics
Executive Summary

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Over the past several decades shape memory alloys, such as Nitinol, have been extensively studied for their thermoelastic martensitic transformations, or "two-way memory effect". The recent introduction of CuZnAl SMA developed by the Schuh lab at MIT provides a low-cost alternative with similar mechanical characteristics. This material, in addition to its SMA characteristics, is solderable, can be produced with wire thicknesses as low as 100um, has an electrical conductivity of 5.4*10^6 (S/m) and possesses a bend radius of 750 um. These unique properties allow it to be integrated into fabrics more readily than Nitinol.

In addition to performing property characterization on the copper alloy wire, several embedding methods were investigated and prototyped to determine mechanical and economic feasibility. Due to limited copper wire availability, Nitinol was used for prototyping. Nitinol wires of various diameters between 37-200um were coiled around a 3 mm screw and baked at 550 C to set its shape. Then it was stretched out and embedded into fabric via silicon casting, knitting, and simple weaving. All methods of embedding were successful, but silicon casting proved most viable of the three (Figure 1 Right). Prototyping proceeded to comparison of 4 types of silicon, and it was determined that the optimal option would be silicon with the lowest thermal expansion.

To test the prototypes, we heated them up to 100 C and calculated the amount of force exerted from the wire contraction back to its original curled shape. The amount of pullback force directly correlated with the diameter of the wire (Figure 1 Left), and we saw pullback forces of up to 2.1N with a single 12 cm wire. This force can be compounded when additional wires are added to the fabric. We also found that we could decrease the amount of force exerted by the wires if we started the wire in a more relaxed state. All prototypes showed pullback forces that increased with increasing wire diameter and amount of wire used.

We expect similar behavior from the copper alloy wire, and its additional desirable properties may make it more suitable for use in shape memory fabrics.

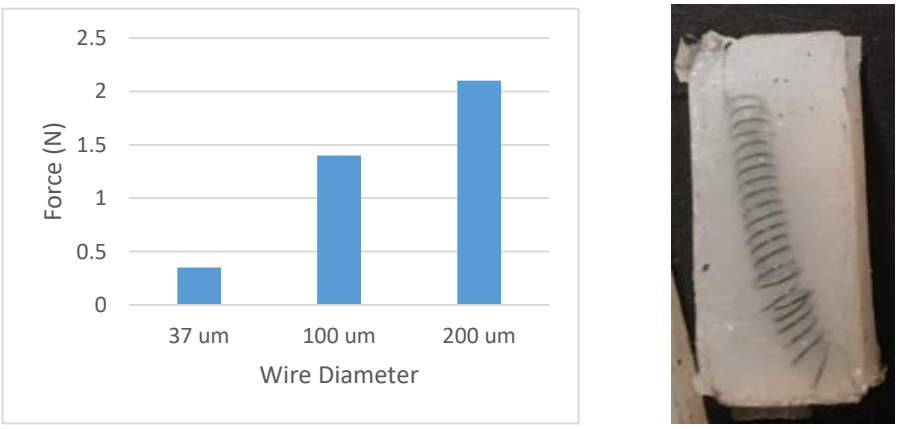

Figure 1: Left) Constriction force from Heated 120mm long Nitinol Wires. Right) Nitinol wire spring cast in silicone.