

CU-AL-NI SHAPE MEMORY SINGLE CRYSTAL WIRES WITH HIGH TRANSFORMATION TEMPERATURE

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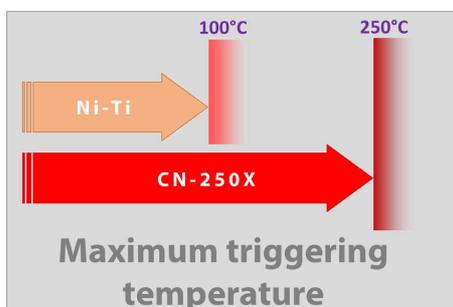
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CN-250X : A New Material With Higher Performances Than Nickel-Titanium SMA

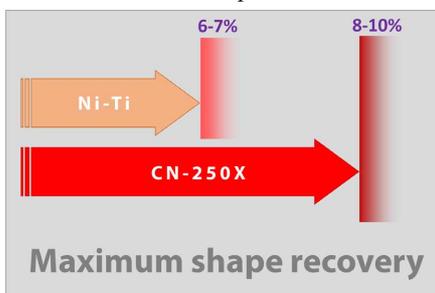
For space mechanisms, main disadvantage of Nickel-Titanium Shape Memory Alloy is the limited transformation temperature. The new CN-250X Nimesis alloy is a Cu-Al-Ni single crystal wire available in large quantity. The triggering of actuators made with this Cu-Al-Ni single crystal wire can range from ambient temperature to 200°C in cycling and even to 250°C in one-shot mode.

Other advantage of CN-250X is a better shape recovery (8 to 10%) than NiTi (6 to 7%).

Nimesis is the first company able to produce this type of material with its new special industrial process.



Availability: round wire diameter 0.5 to 20 mm, length max 1500 mm, industrial production machinable



Advantages: reproductibility, reliability, future sustainability, high quality, made in France

INTRODUCTION

Shape memory alloys (SMA) are recognized as reliable and efficient materials particularly to design actuators. The major drawback of these shape memory actuators is the trigger temperature which is lower than 100°C with standard NiTi alloys. The new Nimesis Cu-Al-Ni single crystal wire shows transformation temperature higher than 100°C and they are available in round section with a diameter from 0.5 mm to 20 mm. The state of the art and a detailed characterization work made for a recent CNES R&T demonstrated that Cu-Al-Ni single crystal wire is a very good candidate for space applications which need trigger temperatures between 100°C and 200°C.



Figure 1 - Cu-Al-Ni single crystal Ø2.2 mm wires made with special Nimesis process

Experimental approach

Cu-Al-Ni single crystal wire was compared with others high temperature SMA, including Ni-Ti-Hf. Some Cu 82.4wt%-Al 13.5wt%-Ni 4.1wt% single crystal samples were mainly tested in tensile mode. The evolution of the deformation during a thermal cycle and with imposed force (shape recovery) was measured. This test was performed for more than 10 thermal cycles. Transformation temperatures were controlled by DSC (Differential Scanning Calorimetry) until 25 cycles.

Single crystals were produced by a Nimesis special industrial process. Dimensions of the wires were 2 mm in diameter, and 300 mm length.



Figure 2 - Test bench used for thermal cycling of pre-stressed single crystal samples

Tensile tests Results

Figures 3 and 4 show results of tensile tests at room temperature and at 220°C.

Figures 5 and 6 present transformation temperatures and deformation as a function of the number of thermal cycles.

Contrary to other High Temperature Shape Memory Alloys, deformation and transformation points remain constant until 25 cycles and probably over (test to be done).

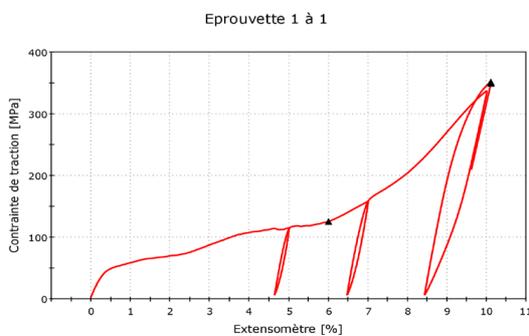


Figure 3- Tensile test of Cu-Al-Ni single crystal sample at room temperature

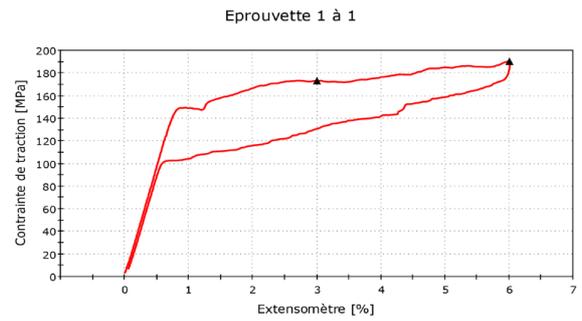


Figure 4 - Tensile test of Cu-Al-Ni single crystal sample at 220°C

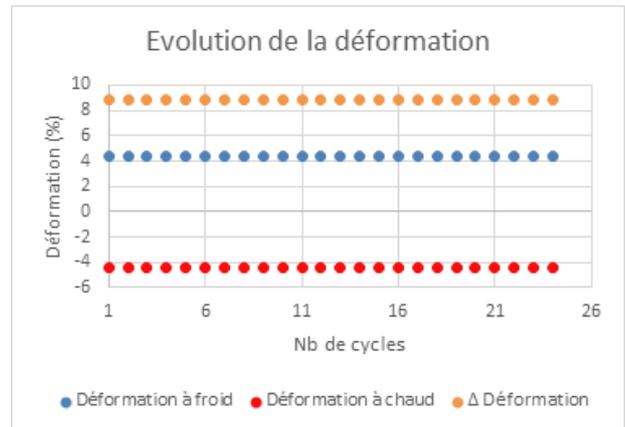


Figure 5 - Evolution of deformation for a prestressed Cu-Al-Ni single crystal (150MPa) and during thermal cycling between 25°C and 250°C

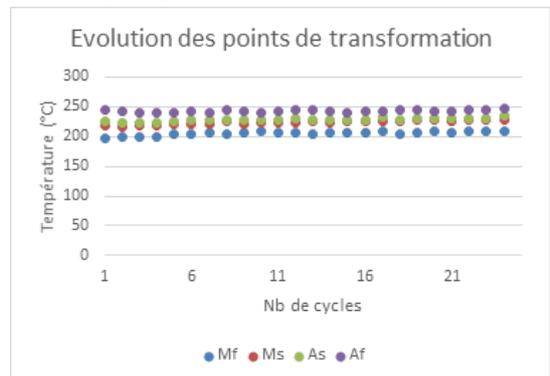


Figure 6 - Evolution of transformation temperatures for a prestressed Cu-Al-Ni single crystal (150MPa) and during thermal cycling between 25°C and 250°C

DSC tests Results

Figure 7 shows the evolution of transformation temperatures (As, Af, Ms, Mf) for three metallurgical states: polycrystalline (before monocrystallisation),

single crystal (after monocrystallisation) and heat treated single crystal. The treatment after monocrystallisation induces a slightly increase of temperatures.

Figure 8 show the evolution of temperatures during thermal cycling between 25 to 200°C.

The transformation temperatures are more stable in cycling when the maximum temperature is limited to 200°C.

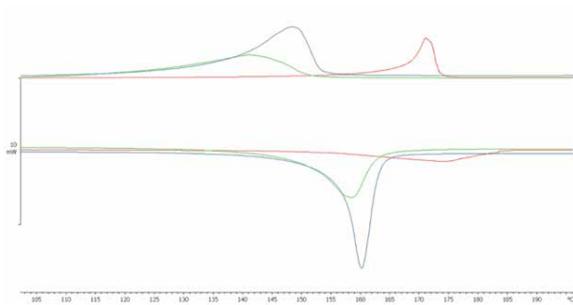


Figure 7 - Evolution of triggering temperatures for different metallurgical states (a-polycrystal, b-single

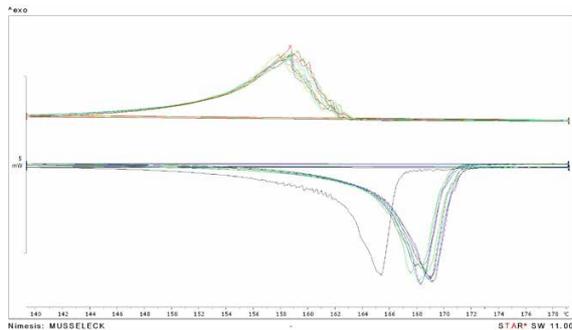


Figure 8 - Examples of actuators made with Cu-Al-Ni single crystal wire

CONCLUSION

Results obtained with new CN-250X by Nimesis showed a very good stability during the thermal cycling in terms of shape recovery (8 to 10%) at 150MPa for trigger temperature below 200°C.

Higher temperatures (until 250°C) can be used for one-shot applications or for applications with a small number of cycles.

Cu-Al-Ni single crystal wire seems to be very interesting to design high temperature actuators,

thermal safety devices, locking-unlocking devices, and deployment mechanisms. Nimesis is now able to manufacture Cu-Al-Ni single crystal wire (diameter between 0.5 to 20 mm) in large quantity with a new industrial process (patent pending), controlling the entire process from alloy casting to wire grinding. This allows supplying High Temperature SMA over the long term.

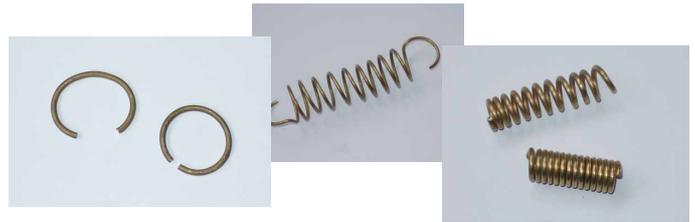


Figure 9 - Examples of actuators made with Cu-Al-Ni single crystal wire