University of Rijeka
FACULTY OF ENGINEERING

međunarodni znanstveno-stručni skup
19. Ružičkini dani
DANAS ZNANOST – SUTRA INDUSTRIJA
21. – 23. rujna 2022. | Vukovar, Hrvatska

EFFECT OF SILVER ADDITION ON Cu-BASED SHAPE MEMORY ALLOYS

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ABSTRACT

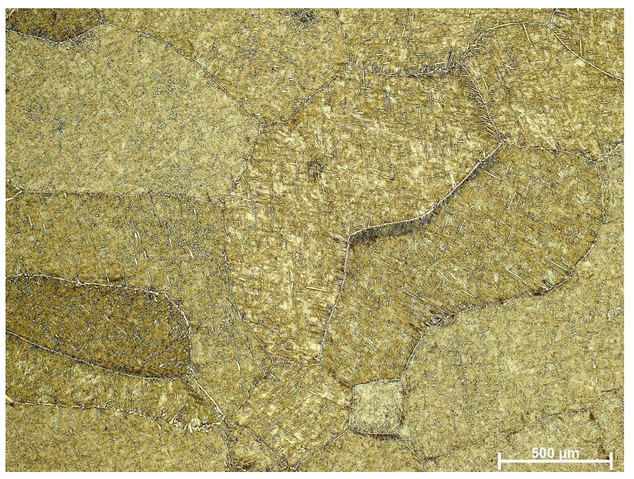
Shape memory alloys are a special type of materials that, when deformed below a certain temperature, can return to their original shape before deformation simply by heating. Alloys with this atypical property are used as functional materials in temperature sensors, actuators and clamping devices. SMA materials also have a property called superelasticity. It is rubber like property, but when bent or stretched, it returns to its original shape when the deforming force is removed. SMA alloys with high superelasticity are used in electrical and electronic equipment, as well as in the medical and optical fields. The Cu-Al-Ag ternary alloy was prepared in an electric arc furnace in an argon atmosphere. The microstructure was determined by optical microscope (OM) and scanning electron microscope (SEM) equipped with an energy dispersive X-ray spectroscopy detector (EDS). The martensitic and austenitic transformation temperatures were determined using the Differential Scanning Calorimeter (MDSC). Hardness was determined using Future Tech FM-ARS -F-9000 with FM -700 microhardness tester. The results showed the morphology of a fully formed martensite structure with different types of martensite in quenched Cu-10Al-1Ag sample.

MATERIALS AND CHARACTERIZATION

The Cu-Al-Ag alloy with 10 wt.% Al and 1 wt.% Ag was prepared in a electric arc furnace in the argon atmosphere. The raw materials used for melting were pure copper (Cu) with a purity of 99.9%, aluminium (Al) with a purity of 99.5%, and silver (Ag) with a purity of 99.99%. The alloy was remelted 4 times for better homogenization and then cast into a cylindrical mould with dimensions of 8 mm x 12 mm. Heat treatment was performed at 900°C for 30 minutes, followed by quenching in water. Samples for microstructure investigations were grinded on 600#, 800# and 1200# SiC abrasive and then polished with 3μm and 1μm diamond paste. To reveal microstructure prepared specimens were etched using 2,5g $FeCl_3$/48mL CH_3OH/10 mL H_2O solution. The microstructure of characteristic states of investigated alloys was observed using an optical microscope Axio Vert A1 light microscope with the AxioCam ERc 5s microscope module, as well as with Scanning Electron Microscope EVO MA10, equipped with Energy Dispersive X-ray Spectroscopy (EDS) detector. Microhardness of investigated alloys was determined using the Future Tech FM-ARS -F-9000 with FM-700 microhardness tester with HV 100g and dwell time of 15s. Transformation temperatures were determined by Modulated Differential Scanning Calorimeter (MDSC) Mettler-Toledo 822e. Dynamic measurements were performed through 2 heating/cooling measurements, in an inert atmosphere and with a heating/cooling rate of 10 K/min.

Table 1. Microhardness of Cu–Al–Ag SMA alloys

Hardness	***HV***					
Sample no.:	***1***	***2***	***3***	***4***	***5***	***Average***
Cu10Al1Ag As-cast state	*314.94*	*292.65*	*284.43*	*295.89*	*307.84*	*297.34*
Cu10Al1Ag Quenched state	*278.57*	*284.55*	*270.88*	*269.11*	*280.45*	*278.00*



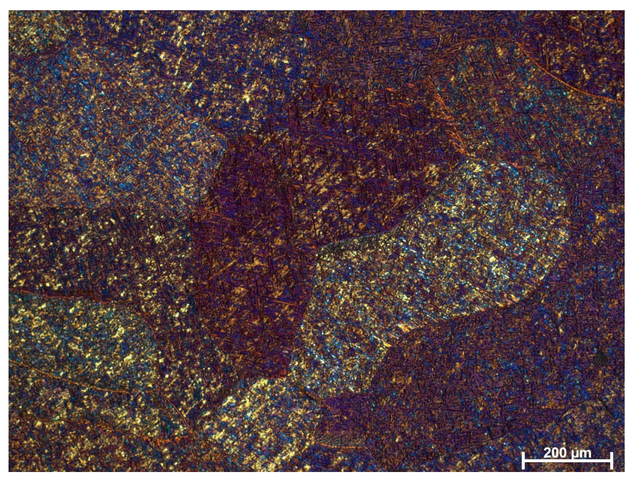


Figure 1. OM micrographs of As-cast Cu-10Al-1Ag SMA alloy (BF. and POL., magnification 100x)

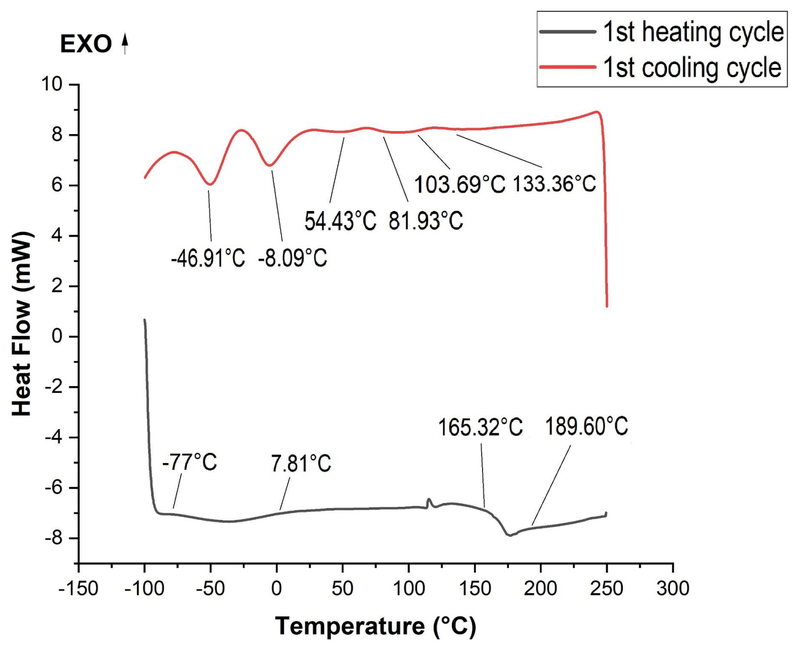


Figure 2. DSC curves of as-cast Cu-10Al-1Ag SMA alloy

Table 2. Experimentally determined overall compositions with SEM-EDS

Experimentally determined composition (wt.%)			
Sample:	***Cu***	***Al***	***Ag***
Cu10Al1Ag As-cast state	*89.46*	*9.61*	*0.93*

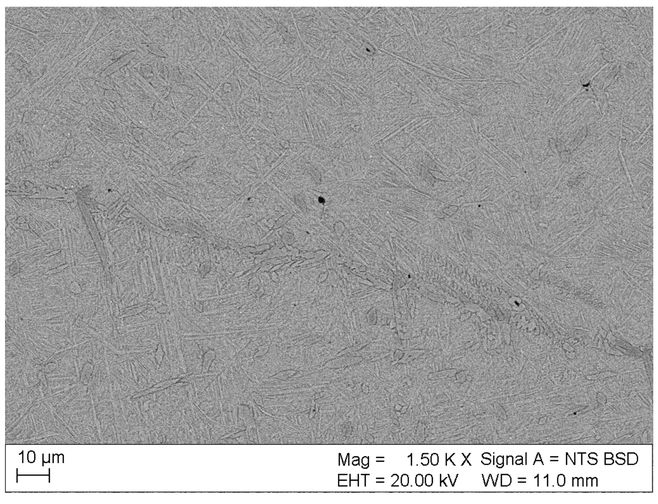


Figure 4. SEM micrograph of as-cast Cu-10Al-1Ag SMA alloy (magnification 1500 x)

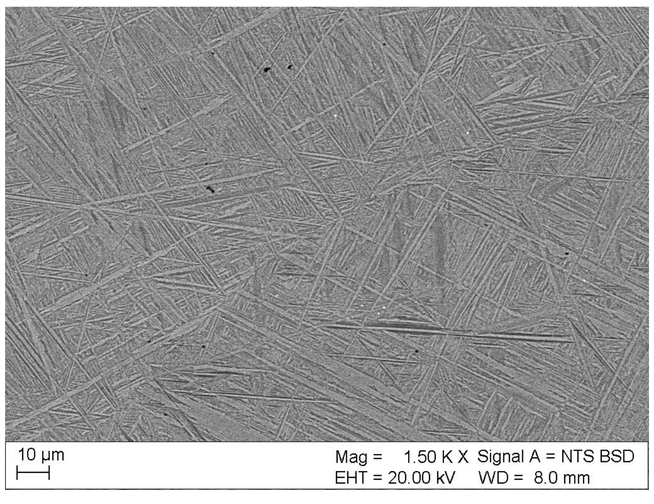


Figure 5. SEM micrograph of quenched Cu-10Al-1Ag SMA alloy (magnification 1500 x)

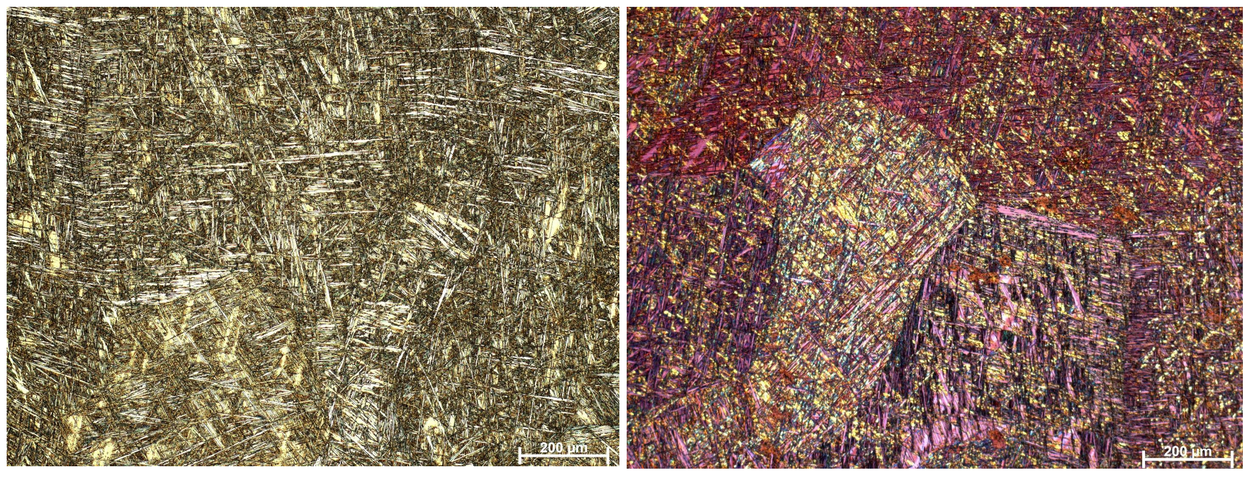


Figure 3. OM micrographs of quenched Cu-10Al-1Ag SMA alloy (BF. And POL., magnification 100x)

CONCLUSION

Results showed intensive formation of martensitic structure in Cu-10Al-1Ag alloy in as-cast as well after heat treatment at 900°C. In both samples, the zig-zag martensitic groups, characteristic for β1’ type of martensite, as well as coarse variants which are characteristic for γ1’ martensite were observed. DSC cruve is showing multipull peeks on the cooling cycle. It can be interpert as formation of multiple typse of martensite. Results of microhardness testings of Cu–Al–Ag SMA alloys are showing that materials in heat treated state is softer then in As-cast state.