Nanocrystalline, fibrous structure of electrodeposited amorphous alloys of W with Ni, Co and Fe

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The amorphous alloys of W with Ni, Co and Fe exhibit some useful properties such as high resistance to corrosion and wear, and premium hardness. Ni alloy is especially interesting because of its noble appearance. It is seen as an environmentally safe substitute for hard chromium plating, and a new material for the microelectromechanical systems (MEMS).

Recent scientific interests in these amorphous / nanocrystalline alloys are focused on their structure and on the increase in the tungsten content (1,2). The aim of this work was to find out what stands behind the amorphousness of the electrodeposited tungsten alloys with the iron group metals.

EXPERIMENTAL

For the electrodeposition of the tungsten alloys we have been using the citric-ammonia solution. In this bath, the coatings of a very good quality can be obtained. By using the appropriate current pulsing and/or the appropriate bath composition, the content of tungsten, the deposition rate, and the grain size can be changed in a rather wide range (3-6).

The experiments done included X-ray diffractometry, scanning tunneling microscopy, EDX analysis, scanning electron microscopy, and the measurements of microhardness. The alloys were deposited at 65 ^{o}C as thin, several-micrometer-thick layers on copper, Cu/Zn alloy and gold. Current density was 70 mA/cm^2.

RESULTS

All examined alloys, including those of mixed Ni-Fe-W composition, were found to have the nano-crystalline structure. Unexpectedly, the nanocrystals were rather of fibrous shape. This conclusion was made after a comparison of the scanning electron- and scanning tunneling micrographs. The most distinct fibers were seen for the Ni-W alloys. The thickness of the fibers was in the range of 5 - 25 nm.

A typical scanning tunneling micrograph is presented in Figure 1 for the Ni-Fe-W alloy of composition 40/40/20 at. %.

A SEM image of the cross-brake surface of the same alloy is presented in Figure2. The layer of the alloy is circa 10 μm thick.

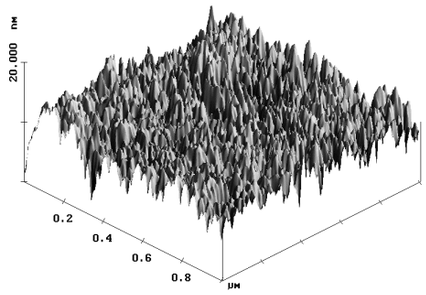

Figure 1
STM image of a layer of the electrodeposited Ni-Fe-W amorphous alloy

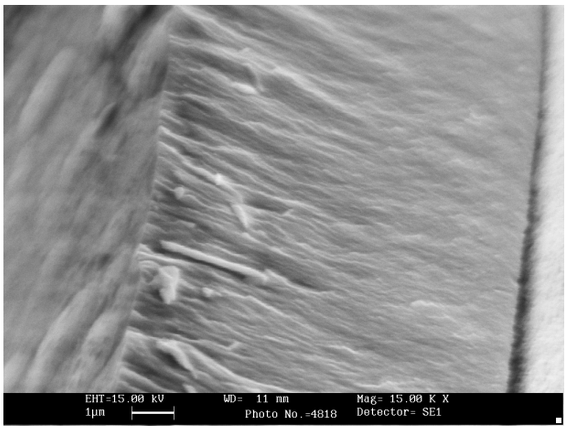

Figure 2
SEM image of the cross-brake surface of the Ni-Fe-W alloy. Bundles of fibers, not individual fibers, are seen in the picture.

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