

# Electrical anisotropy enhancement in W-Cu based columnar films

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GLAD thin films produced from a single particle source often exhibit anisotropic physical properties, which are closely linked to the elliptical cross-section of the inclined columnar structure [1]. Involving two particle sources, the growth mechanism becomes more complex and anisotropic behaviors can be either reduced or enhanced depending on the deposition conditions. In this study, we focus on the GLAD co-deposition process leading to anisotropy of the films resistivity. To this aim, W-Cu thin films are deposited by GLAD co-sputtering using two separated W and Cu targets. Angles between target axes and the substrate normal are both fixed at 80°. The current intensity of W target is fixed at  $I_W = 140$  mA, whereas that of Cu target is systematically changed from  $I_{Cu} = 40$  to 150 mA and finally adjusted in order to tune the copper concentration in the inclined columnar structure. Top views and cross-section observations by SEM of as-deposited films show that bi-component columns can be obtained with a columnar fanning closely related to W and Cu target current intensities. The effect of the Cu current intensity on physico-chemical characteristics of the films is systematically studied. Composition is determined by XRF, structural morphology and surface roughness are examined by SEM and AFM. Electrical properties are thoroughly investigated by the four-probe method using the van der Pauw configuration. It is shown that these porous W-Cu nanostructured films display a significant electrical anisotropy connected to the microstructure of the tilted columns. To favor a more porous structure with a highest electrical anisotropy, one of the metal (Cu) is finally removed by using a wet chemical etching technique. After etching, the influence of structural morphology on the electrical anisotropy of W-Cu nanostructured films is soundly noticed. It is also compared to the electrical properties of single W GLAD thin films. As a result, the electrical resistivity anisotropy measured at room temperature is  $1.8 \pm 0.1$  for as-deposited W-Cu films and reaches  $2.8 \pm 0.1$  after the etching procedure. A metallic-like behavior is measured for all films with a resistivity at room temperature ranging from  $1.66 \times 10^{-5}$  Ohm.m to  $4.28 \times 10^{-5}$  Ohm.m after etching.

## Keywords:

GLAD, co-sputtering, W-Cu, enhanced anisotropy, resistivity, wet chemical etching.

[1] Hawkeye et al., Glancing Angle Deposition of thin films: engineering the nanoscale, John Wiley & Sons, Ltd, Chichester, UK, 2014.