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Three-Dimensional Surface Stereometric Analysis of Ni–Cu Films with Different Cu Contents

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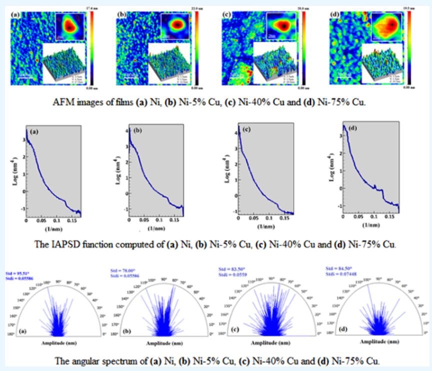
ABSTRACT: The purpose of this work is a stereometric analysis of Ni–Cu thin films to obtain the three-dimensional (3D) microtexture surface based on atomic force microscopy (AFM). Four Ni–Cu thin films on glass and silicon substrates were prepared by a capacitively coupled RF-PECVD system with a 13.56 MHz power supply. The AFM data of the samples were stereometrically analyzed, and the surface microtexture was determined according to the definition of relevant parameters in the standards ISO 25178–2:2012 and ASME B46.1–2009. All microtexture features can be implemented in numerical programs to simulate advanced microtexture models under specific microstructure and composition conditions. The results can be used to validate theoretical models for predicting or correlating the surface parameters of nanostructures. The Ni–Cu films with 40% Cu have a more irregular surface; hence, the maximum Sq value of the as-deposited Ni–Cu films is about 81.24 μm. The core roughness height Sk is calculated as a difference between two extreme levels (maximal and minimal) of the surface core, for which Ni–Cu films with 40% Cu have a maximum value of 183.4 μm. Since the surface kurtosis (Sku) of all sample films was lower than 7, there are very small peaks or valleys on the film surface and for Ni–Cu films with 5% Cu with a value of 3.568. With increasing Cu content, the height distribution histograms of films show more uniform distributions.



1. INTRODUCTION

The importance of the physical phenomena that occur in thin films is first due to the broad perspective of the application of thin films in practice (ultrafrequency engineering, optoelectronics, microelectronics, etc.) and, second, the possibility of obtaining the information needed to solve some basic problems in solid state and surface physics. The Ni–Cu thin films have been the subject of many studies. Several interesting features of the Ni–Cu system have been reported.[1−5] As is known, optical properties of nanoparticles strongly depend on the morphology of the nanostructure. However, there is a dearth of advanced microtexture and fractal/multifractal analysis. Therefore, it is important to study these structural parameters for practical applications. Recently, advanced studies have contributed to a deeper understanding of the three-dimensional surface microtexture of thin films, which promotes the development of nanomaterials with major technological applications.[6,7] Advanced techniques of characterization are at the center of scientific attention.[8−10] Different studies showed that the three-dimensional surface microtexture can be described using stereometric[11] and fractal/multifractal analyses[12−14] with a minimal set of surface parameters. Imaging by AFM can bring outstanding results in the field of research and analysis of nanostructured surfaces, especially in the case of thin films.[15−17] As the main goal, the 3D surface micromorphology of Ni–Cu thin films was investigated using AFM and stereometric analyses. Details on the experimental techniques and the deposition conditions are given in Section 2. The structural properties were studied by scanning electron microscopy (SEM) (Section 3.1), while the surface roughness was investigated by using atomic force microscopy (AFM) (Section 3.2). The conclusions are presented in Section 4.

2. MATERIALS AND METHODS

2.1. Empirical Techniques. In this article, Ni–Cu nanoparticles with similar amounts of Ni and different amounts of Cu concentration were deposited by a capacitively coupled RF-PECVD system with a 13.56 MHz power supply. The reactor includes two electrodes with different target sizes of Ni and Cu because the fed electrode was the smaller electrode in the first and second stages of film deposition, respectively. The distance between the nickel and copper targets and the substrate was 6 cm. The body of the stainless steel chamber was connected to the ground through a larger

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