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Study through STM of AuN films grown using PAPVD by pulsed ARC

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Due to the Au conductivity, good electric characteristics of AuN are expected, which could generate applications in the electronic industry. AuN films were grown through the Plasma Assisted Physic Vapor Deposition (PAPVD) by the pulsed arc technique. Films were chemically characterized through X-Ray Photoelectron Spectroscopy (XPS) in order to determine its composition. Using Scanning Tunneling Microscopy (STM), and due to the electric conductivity of the films, images and I-V curves were obtained in order to observe the morphology of the films and to obtain the gap value, respectively.

Keywords: Gold Nitride; STM; electric conductivity.

Debido a la conductividad del Au, se espera tener unas buenas características eléctricas del nitruro de oro (AuN) y generar aplicaciones en la industria electrónica. Por la técnica de deposición física en fase de vapor asistida por plasma (PAPVD) por arco pulsado, se crecieron películas de AuN. Se caracterizaron químicamente por espectroscopía Fotoelectrónica de rayos X (XPS) para observar la composición de las películas, por microscopia de efecto túnel (STM) se obtuvieron imágenes en las que gracias a la conductividad eléctrica de la película se puede detallar su morfología, además de esto se presentan curvas I-V, de las cuales se puede obtener el valor del gap.

Descriptores: Nitruro de Oro; STM; conductividad eléctrica.

PACS: 73.63.Bd

1. Introduction

Hard films are used to improve the materials surfaces and to increase their use and resistance to corrosion [1]. Metallic nitrides have unique properties that are convenient for different applications, such as: high hardness, high melting point, chemical stability.

Gold is a very attractive material to use in micro and nanotechnologies due to its role as a substrate for self-assembled systems and its use as a metallic interconnection between nanostructures [2] Gold nitride is a compound recently synthesized [3, 4] by ionic implantation.

Highly oriented pyrolitic graphite (HOPG) is widely used in measurements by the scanning tunneling microscope (STM) [5] as a standard sample to check the atom-resolving ability of the apparatus. HOPG has the following good properties as a standard sample for STM. It easily offers an atomically flat and clean surface just by peeling off the surface layer with a mending tape. It is electroconducting, and also its surface corrugation is largely due to the presence of surface dangling bonds compared with other materials, such as metallic samples. Some unusual related phenomena have been reported in the STM investigation of HOPG, such as the giant corrugation and many artefacts. Hence, the electronic state of HOPG was not investigated by STM in detail [6].

AuN films were produced through the PAPVD technique by pulsed arc and were deposited on stainless steel 304. The XPS technique was used to chemically characterize the films. Narrow N1s and Au4f spectra are shown to find the AuN phase of the thin films. In order to assess the validity of the results, the electronic property of AuN, it's showed HOPG results in scanning tunnelling spectroscopy (STS) measurement.

2. Experimental Setup

The PAPVD system by the arc pulsed technique with the configuration of electrodes face to face was used, with a non commercial power controlled system that systematically performs the discharge. The faced electrodes were separated by 0.4 cm; the gold cathode was of a 99,9% purity; and the anode was made of stainless steel 304. The superficial chemical analysis was made using a Thermo VG ESCALAB 250 with AlKα photoelectron energy, subjecting the films to a high vacuum (10_{-11} mbar) for two hours before obtaining the spectra. A sputter etching was made using Argon ions of 5 μA ionic current and 3 Kv power. The peaks' deconvolution was realized using a Lorentzian-Gaussian function through Advantage VG software, and the Shirley background type was used for the fits. The resolution of the equipment is 0.2 eV. Park Scientific Instruments equipment model AutoProbe CP was used for the STM analysis. Images were made using a Pt - Ir tip with a scanning area of 1 μm^2 and a set point of $0.5\ nA$, and by applying a 1 V bias voltage to the sample. The images of the I-V curves were obtained in environmental conditions of 75% relative humidity and a temperature of 20°C. The data for the I-V curves was obtained in 10 random points of the sample in the range from -1V to 1V.

3. Results and Discussion

Narrow spectra, N1s and Au4f, are shown in Figs. 1 and 2, which were taken after 20 minutes of the sputter etching. In Fig. 1, the N1s narrow spectrum is shown. Observe two peaks corresponding to 398.1 eV and 401.1 eV energies. Re-

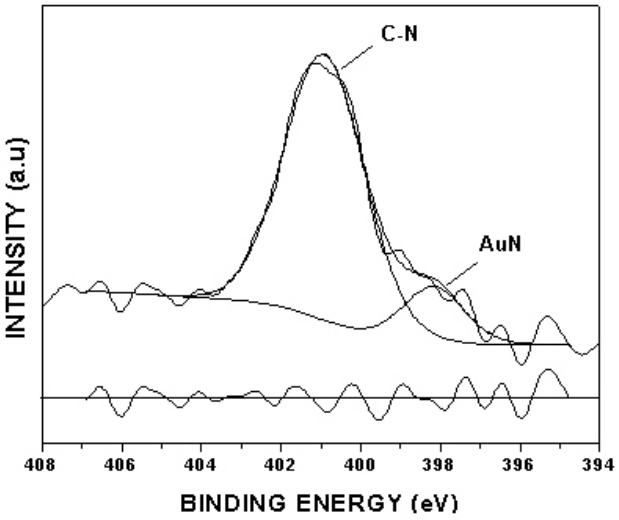

FIGURE 1. Narrow spectrum for N1s.

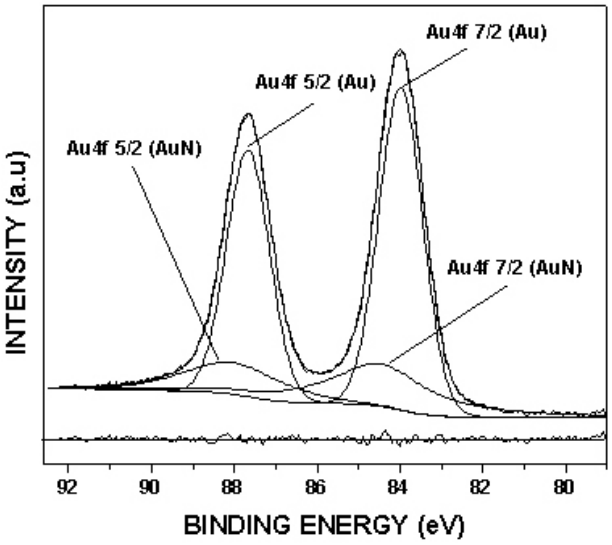

FIGURE 2. Narrow spectrum for Au4f.

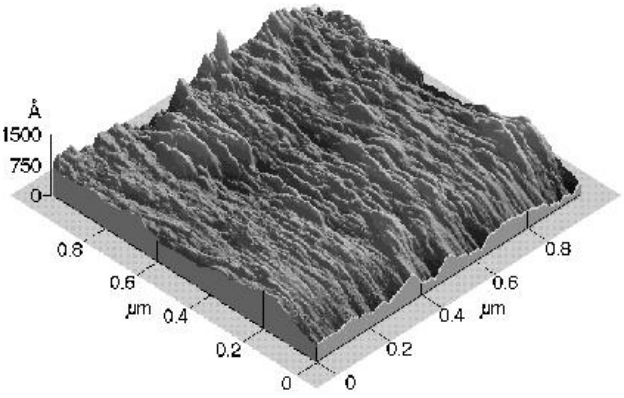

FIGURE 3. Morphological image AuN.

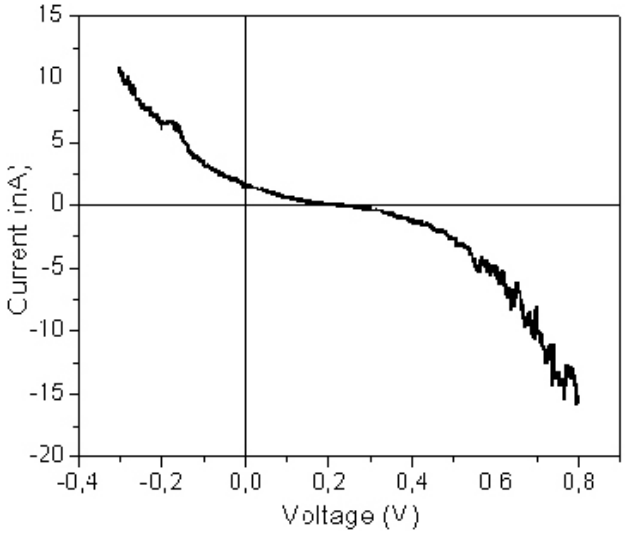

FIGURE 4. HOPG I-V curve.

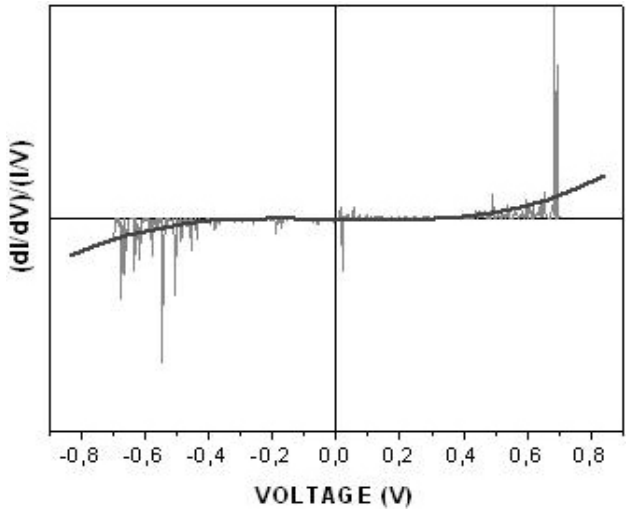

FIGURE 5. AuN (dI/dV)/(I/V) curve. Black line is fit of experimental date.

ports about the low energy peak are found in literature by Devia [7] and by S. Krishnamurthy [8]. The high energy peak is assigned as carbonitride [10]. The Carbon presence is due to reactor impurities and after exposing the film to the environment. Also, the content of CN+OC (9.33) is smaller than the content AuN+Au (90.77). Figure 2 shows the Au4f narrow spectrum, which presents the characteristic double Au4f7/2 and Au4f5/2, centered at 83.99 eV and 87.68 eV, respectively. In each peak, a widening that was deconvoluted was found, and as result, the peaks shown in Fig. 1 were obtained. These centered at 84.7 and 88.3 eV, respectively, satisfying the characteristic separation of the Au4f level (3.6 eV). In Fig. 3 a morphological detail of the coating is observed, and it shows regularity in the analyzed regions, so it is possible to conclude that the surface has conductivity. Because the literature lacks information about AuN I-V curve, Fig. 4 shows the HOPG I-V curve in order to validate the exper-

imental data. This figure agrees with the results presented by other authors [10, 11], indicating that the tests were taken correctly. Figure 5 shows the (dI/dV)/(I/V) curve of the AuN film, which provides a convenient normalization of Tunneling Spectroscopy data [12]. The experimentally obtained gap value Fig. 5) is about 0.34 eV [11]. By comparing the conductivity for other materials, one can conclude that AuN is a good conductor [13].

4. Conclusion

AuN films were grown using the pulsed arc technique, deposited on stainless steel 304 substrates. This is a new technique to grow this material, as there are not reports in literature. XPS analysis confirmed the $AuN_{0.6}$ phase presence, showing the binding energies for the narrow spectra N1s and Au4f. The (dI/dV)/(I/V) curve lets us calculate the gap value, and the morphological image shows the conductivity of the film. From these results, it was possible to deduce that this new coating has a conductor behavior.

Acknowledgments

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