

Formation and characterization of Amorphous Silicon (a-Si) and Aluminum (Al) thin films for the development of Spacer Lithography Technique

Laís O. de Souza*, Andressa M. Rosa, José A. Diniz

Abstract

This work presents the formation and characterization of Al thin films obtained by three different methods of deposition (DC magnetron sputtering, e-beam evaporation and thermal evaporation) and a-Si thin films deposited by ECR-CVD technique.

Key words:

Amorphous Silicon thin films, Aluminum thin films, Spacer Lithography.

Introduction

In this work, hydrogenated amorphous silicon (a-Si:H) and aluminium (Al) thin films (10-200 nm thick) have been obtained and characterized. Al films were deposited by three different methods and characterized by Atomic Force Microscopy (AFM) and Four-Probe technique. a-Si:H films were deposited by ECR-CVD and characterized by Fourier Transform InfraRed Spectroscopy (FTIRS), Ellipsometry, Interferometry and AFM. Also, the etch rate (ER) a-Si:H films were determined in three different etch process such as RIE, ICP and ECR. These films (Al and a-Si:H films) have been used to implement the spacer lithography (SL) technique, which is used to define the silicon nanowires (SiNWs) with a minimum width of up to 10 nm¹. After, with these SiNWs, 3D MOS devices can be obtained such as FinFETs.

It is known that metallic films with highest resistivity must present lowest grain size and surface roughness. In this context, the best of aluminum mandrel material for our SL method is the thermal evaporated film, because, from results shown in Chart 1, presents the highest resistivity of 13.2 μΩ.cm, the lowest roughness and the smallest grain size values of 5.3 nm and 22 nm, respectively, between three different methods to get the Al films. Typical FTIR spectra of a-Si films deposited by ECR-CVD in different weeks were carried out. From the spectra, absorption peak at 2100 cm⁻¹ due to Si-H bonds are observed, indicating the formation of hydrogenated silicon film. Ellipsometry analysis was used to extract the refractive index and thickness. The average refractive index and the thickness values of a-Si films, which were deposited in different weeks, were of 4.1 and between 150 nm and 160 nm. The values of refractive index of about 4.1, confirm the formation of hydrogenated silicon films. Furthermore, all results confirm the reliability of the ECR-CVD process to get the a-Si films.

Afterwards to obtain the a-Si spacers, the etch rate of three processes in RIE, ICP and ECR systems were determined being of 30nm/min, 120nm/min and 60nm/min, respectively.

Results and Discussion

Image 1 presents the process steps to get the SiNWs, using the SL technique. In our SL technique, the spacer and the mandrel are a-Si and Al thin films, respectively. The a-Si and Al thin films were deposited on p-type Si (100) wafers. The substrates were cleaned with a standard RCA method.

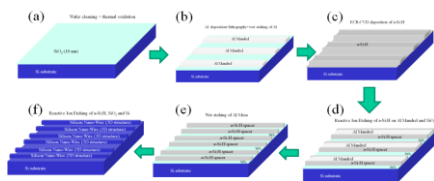


Image 1. The process steps of our SL technique, where spacer and the mandrel are the a-Si and Al thin films, respectively.

The electrical resistivity (extracted from four probe method), the roughness and grain size (extracted from 2D surface topography using AFM analysis) values of Al films, which were deposited by DC magnetron sputtering, e-beam evaporation and thermal evaporation, are presented in Chart 1.

Chart 1. The resistivity, the RMS roughness and grain size values of Al films deposited by three different methods.

Deposition methods	ρ ($\mu\Omega$.cm)	RMS Roughness (nm)	Grain size (nm)
DC magnetron sputtering	3.9	11.5	33
e-beam evaporation	12.7	5.4	24
thermal evaporation	13.2	5.3	22

Conclusions

In conclusion, we can observe that the Al film deposited by thermal evaporation is the most suitable for SL technique. We can also observe that from FTIR and ellipsometry results, a-Si films are hydrogenated amorphous silicon, so, both films can be used in our SL technique

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