

Plasma surface modification of ZnSnN₂ thin-films for opto-electronic applications

Teena Jangid, Monalisa Ghosh, G. Mohan Rao

Department of Instrumentation & Applied Physics, IISc, Bangalore

e-mail: teenajangid@iisc.ac.in

Reactive radio frequency magnetron sputtering was used for growth of ZnSnN₂ thin-films on Si and glass substrates at 100°C and 400°C. The effect of Ar plasma-treatment on surface morphology, roughness, optical and photo-conductive properties of deposited ZnSnN₂ thin-films has been studied under various plasma conditions. Plasma-treatment experiments were performed in an electron cyclotron resonance plasma (ECR) system under three conditions (microwave power of 300 W, 350 W, 350 W with 100 V dc substrate bias). Scanning electron microscopy (SEM) and atomic force microscopy (AFM) were used as key techniques for analyzing the changes in the surface morphology and roughness of samples before and after Ar plasma-treatment. The as-deposited films at both substrate temperatures were smooth (~2-4 nm root mean square [rms] roughness by atomic force microscopy). Although no substantial surface micro-roughening has been observed after Ar plasma-treatment, a systematic change in sample roughness values was found, as we increased microwave plasma power and applied 100 V dc substrate bias at 350 W microwave plasma power. Highest value of grain size was found for as-deposited films (at both substrate temperatures), which decreases drastically from 42 nm to 10 nm after 300 W microwave Ar plasma-treatment. Grain size further reduced to 8-7 nm for 350 W Ar plasma but when 100 V dc bias was applied, the grain size increases to 12 nm for 400°C ZnSnN₂ thin-films, where as, further reduction of grain size to 5 nm was observed for 100°C ZnSnN₂ thin-films. Maximum absorbance in the visible region was observed

for the samples treated with 300 W microwave plasma for both substrate temperatures, where as, absorbance of as-deposited and films treated at other conditions were not much different. With Ar plasma-treatment, the largest dark and photo-current values were observed for untreated film and for the film treated in Ar gas plasma at 350 W and 100V dc bias, where as, lower values of dark and photo-current were observed for other plasma treatment conditions.

These observations suggest that surface modification of the ZnSnN₂ thin-films can be used to control their morphological and electronic properties.

	400°C samples		100°C samples	
	Roughness, (nm)	Grain size, (nm)	Roughness, (nm)	Grain size, (nm)
As-deposited	4.2	42	2.2	43
After Ar plasma-treatment at 300 W power	3.5	10	1.8	9
After Ar plasma-treatment at 350 W power	3.9	7	2.1	8
After Ar plasma-treatment at 350 W power with 100 V dc bias	3.0	12	1.1	5

Table 1. Variation of surface roughness (RMS) and grain size for ZnSnN₂ films (deposited at substrate temperature of 400°C and 100°C) with different microwave plasma treatment conditions.