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Optical Studies on TiN_x Films Deposited on Si by Reactive dc Magnetron Sputtering

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Titanium nitrides (TiN_x) belong to a class of refractory metal nitrides with high melting points, high electrical conductivities, and extreme hardness.(1) The refractory nature of the compounds and their spectral selectivity made them useful materials for high-temperature photothermal conversion of solar energy.(2) Also, the combination of high electrical conductivity and resistance to aluminum migration of the compounds makes them attractive as a thin film diffusion barrier between aluminum and silicon or silicide contact points in semiconductor device process.(3)

In the present work, titanium nitride thin films were deposited on Si(001) substrates with thicknesses in the 3000-4000 Å range by reactive dc magnetron sputtering with varying dc power, substrate temperature, and nitrogen partial pressure. Crystalline structure of the samples was monitored using X-ray diffraction (XRD)(4) and their chemical compositions were determined using photoemission spectroscopy(5) and XRD. The lattice constants of the prepared cubic TiN_x ($0.7<x<1.2$) are found to vary linearly with the nitride composition as is shown in Fig. 1. The optical constants of the films were measured by spectroscopic ellipsometry in the 1.5 - 5.5 eV region. It is found that the onset of the interband transitions of the compounds shifts gradually to low energies as the nitride composition increases as is seen in Fig. 2.

Dielectric functions of the samples in the intraband transition region were fitted by the Drude model(6) and their free-electron parameters were obtained. As is seen in Fig. 3, the screened plasma frequencies of the samples were quite close to the value at which $\varepsilon_1(\omega) = 0$, indicating that the conduction electrons of the compounds behave nearly free-electron-like.

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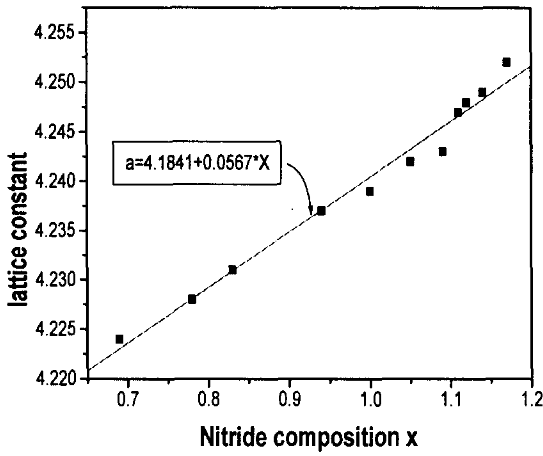

Fig. 1

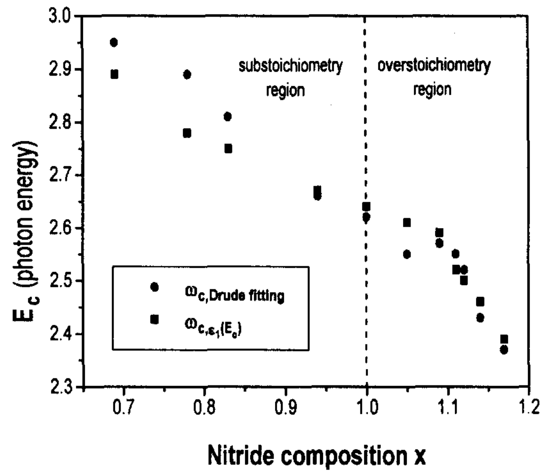

Fig. 3

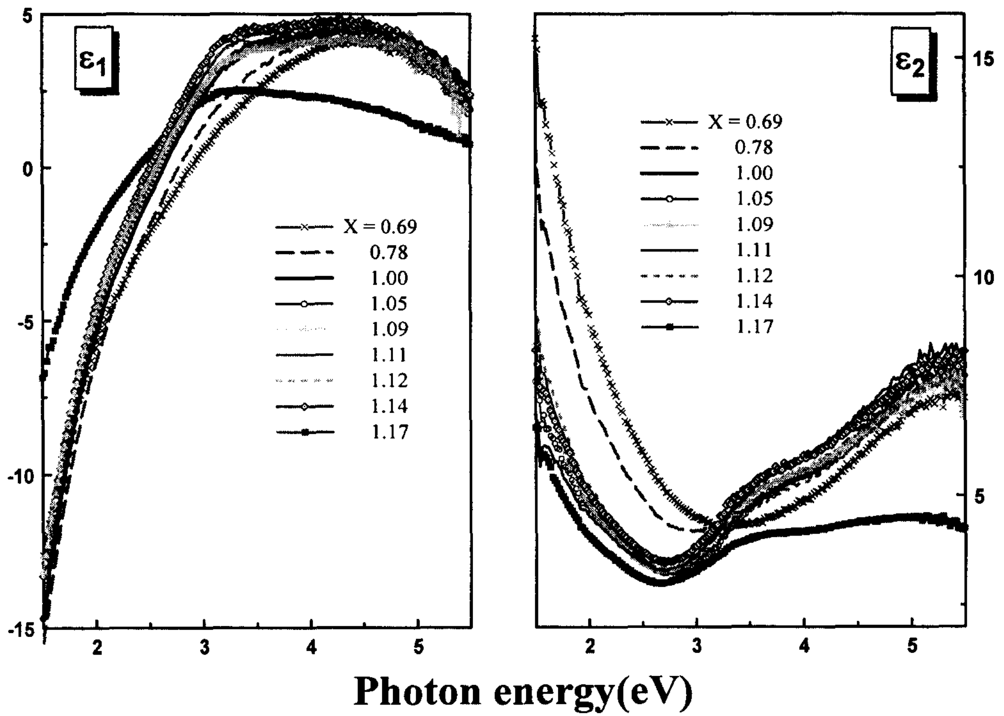

Fig. 2