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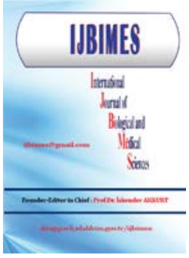

Research Article

An Experimental Investigation of the Formation of Thin Film Ni Silicide by Energy Dispersive X-Ray Spectroscopy and Scanning Electron Microscopy (SEM)#

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Abstract: The objective of this paper is to investigate the formation of metal nickel silicide, by energy dispersive x-ray spectroscopy (EDS) and scanning electron microscopy and X-ray diffraction. The bilayers of Ni and Si (with Ni on top) were deposited on physical vapor deposition (PVD) substrates at temperatures and annealing from 200 to 500°C in steps of 100°C.

The composition profile of the reaction zone and the chemistry of the structure were investigated by scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDS). The XRD profiles shows the formation of structure Ni_3Si in the first and the rapidly transforms to monophase Ni silicides.

1. INTRODUCTION

Metal silicide thin films have attracted attention because of their use as ohmic or rectifying contacts as well as low resistance interconnections in integrated circuits technology [1]. As we reduce the dimensions of the integrated circuits, we are faced with serious problems of formation and deposited of metal film on silicon [1,2].

Among all transition metal silicides $NiSi_2$ shows the smallest lattice mismatch of -0.4 % to Si. These different silicides have great potential for application in metal oxide semiconductors (MOS) [3]. The Ni rich silicides such as Ni_2Si, $Ni_{31}Si_{12}$ and Ni_3Si are found attractive for p-MOS gates on high dielectrics due to their high work functions, while Si rich compositions such as NiSi, Ni_3Si_2 and $NiSi_2$ may be targeted for n-MOS[3].

The Ni-Si system possesses six phases that are stable at room temperature (RT): the metal-rich phases (Ni_3Si, $Ni_{31}Si_{12}$, δ-Ni_2Si, and Ni_3Si_2). [3, 4]

During silicidation, many nickel silicide phases may appear simultaneously [5]. It has been reported that the predominant phases are Ni_2Si, NiSi and $NiSi_2$, form in the ranges 200–350ºC, 350–750ºC, and 750–1000ºC, respectively [6]. however in our case the X-ray diffraction report the sequence of silicide formation by the presence of Ni_3Si phase at 200-270ºC and the formation of NiSi at 350-400ºC.

X-ray diffraction analysis has been carried out to determine the different phases of nickel silicides in the films. Energy dispersive x-ray spectroscopy (EDS) and cross-sectional scanning electron microscopy analysis are used to investigate the change in concentration of diffusing metal element along the thickness of the films.

2. EXPERIMENTAL DETAILS

Ni films were deposited on (111) Si wafers (p-Boron 0.01-0.1 Ω⁄cm) thickn 335-405µm on SILTRONIX substrates. The Si samples were cleaned using organic solutions and etched with dilute buffered HF solution 10% to remove the native oxide on the Si surface before loading into the evaporation chamber. film was deposited by physical vapor deposition (PVD). The base pressure of the chamber was 10^{-5} - $5{\cdot}10^{-7}$ Torr, and the evaporation rate was about 5 Å/s

in a vacuum of better than 10^{-6} Torr. After the metal deposition, the silicide was formed by (rapid thermal annealing in a argon ambient). The first annealing step is performed in the temperature range of 275 to 350°C, For the initial Ni3Si formation. The second higher temperature range of 350 to 400°C annealing step transitions the Ni_3Si to low resistivity NiSi.
The images of the films were obtained in a field emission scanning electron microscope (SEM), with an Energy dispersive X-ray spectrometer (EDS) and the investigation of phases is done by X-ray diffraction.

3. RESULTS AND DISCUSSION

The images of the films were obtained in a field emission scanning electron microscope (SEM) figures 1and 2 show the formation of Ni silicide.

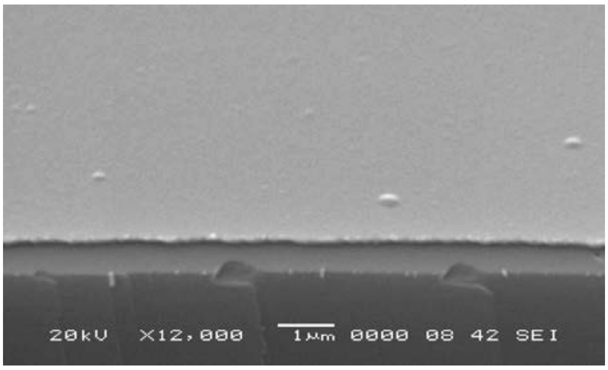

Figure1. *Illustration images of the formation of NiSi thin films.*

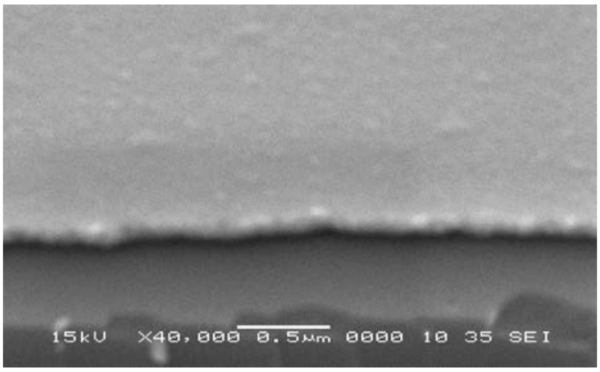

Figure2. *The formation of 100 nm of NiSi thin films.*

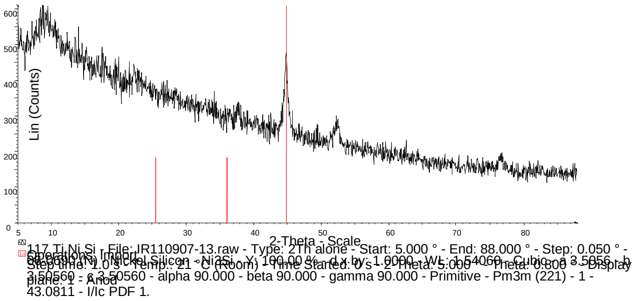

Figure 3. *XRD confirms the presence of Ni3Si phase in first in the sample*

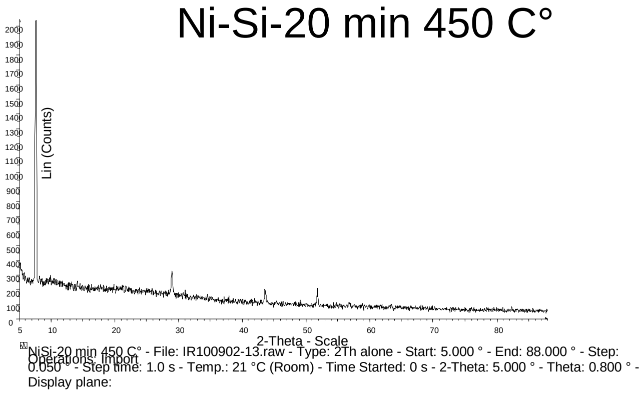

Figure 4. *XRD image shows the transformation of Ni_3Si to the final phase NiSi..*

XRD was performed to investigate the formation of Ni silicide phases revealing a NiSi peak as well as Ni rich phase of Ni_3Si as shown in Fig.3. Energy dispersive X-ray spectrometer (EDS) for determining the depth profile of the chemical composition. The composition profile reveals the surface is Ni rich but there is decrease in Ni concentration as a function of depth. The oxygen concentration is relatively lower than the metal concentrations across the depth. The surface remains rich in Ni and deficient in Si with increase in substrate and annealing temperature to 500°C, as shown in Fig. 4.

4. CONCLUSION

In this paper, we investigated the phase formation sequence upon annealing of a thin nickel deposition, the formation silicide Ni deposited on a Si(111) wafer. The XRD profiles shows the formation of structure Ni_3Si. This phase rapidly transforms into NiSi.

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