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Characterization of Sputtered Ge-Sn Thin Films by High Resolution Methods

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High resolution transmission and scanning transmission electron microscopy (HREM, STEM), high resolution X ray diffraction (HRXRD) and electron energy loss spectroscopy (EELS) have been used to characterize the interfaces of Ge-Sn thin films deposited on Ge substrates. $Ge_{(1-X)}Sn_X$ have been deposited on Ge (001) substrates by using a conventional rf sputtering system. The growth of the thin films has been done at low temperature and using a rf sputtering technique to force alloying of Sn and Ge and prevent Sn segregation to the interface. Three different compositions have been investigated i.e., X = 1, 7 and 14 at.% Sn. X ray diffraction results have been published elsewhere [1] however a direct determination of in growth and in plane lattice parameters as well as the bulk or average lattice parameter are of importance in order to know the structural characteristics of these alloys and for comparison to the results obtained by HRXRD. A CM300 and a Tecnai 200 (FEI®) microscopes have been used for investigation.

Figure 1a shows the interface and Sn containing film between Ge rich layers in HREM mode. The sample contains 7 at. % Sn. The film grows coherently forming no defects at the interface and it is not flat, most likely due to the topography of the substrate. The interface region shows a contrast variation indicating changes in composition (due to Sn and contamination with O and C). Figure 1b shows an enlargement of the indicated area in Fig. 1a. The characteristic “Dumbbells” of Ge in this orientation ([011]) can be clearly seen away from the interface and Sn containing film. Fig. 2a shows the thinnest region of the sample and thus the best area to perform exit wave image reconstruction (TrueImage (FEI®)). The results are shown in Fig. 2c, the images before (Fig. 2b) and after reconstruction are very similar. This is most likely due to the little compositional difference in this interface making delocalization very subtle. Fig. 1c shows a profile of intensity Vs distance taken from the image in Fig. 1b. Calibration of such profiles allows measurement of the in-plane and in-growth lattice parameters. This can be compared to the bulk measurements made by high resolution X-Ray diffraction. The intensity shown in the profile is in principle indicative of the chemical composition of each column in the reconstructed image. An exact determination of composition is possible only for known thicknesses but here they are used to measure the width of the interface layer. A thin Sn-Ge layer can thus be seen with no dumbbells at all followed by a layer with clear dumbbells. The intensity in the interface region becomes clearly smaller most likely due to some contamination by light element such as C or O. The total thickness of the thin film in this sample reaches almost 200 nm. It is composed by an alloyed thin layer and a thicker one made of pure Ge. As the distance from the interface becomes larger, some faults can be observed. Additionally, the film becomes polycrystalline approximately 50 nm away from the interface and amorphous at distances ranging from approximately 150 to 200 nm [1]. HR-STEM images corresponding to the interface of the samples containing 1 and 7 at. % Sn show slight intensity differences in the thin film region containing Sn. Brighter columns can be clearly recognized. Although the contrast difference is visible, its relatively small magnitude suggests alloying of Sn and Ge in the imaged columns rather than Sn segregation [2].

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References

[1] H. Pérez Ladrón de Guevara, A. G. Rodriguez, H. Navarro-Contreras and M. A. Vidal, , Appl. Phys. Letts. Vol. 83, 4942 (2003).
[2] HAC acknowledges support from CONACYT (Proy. 45887), IPN (COFAA and SIP) and LBNL-NCEM for the use of microscopes. MAV acknowledges CONACYT and UASLP.

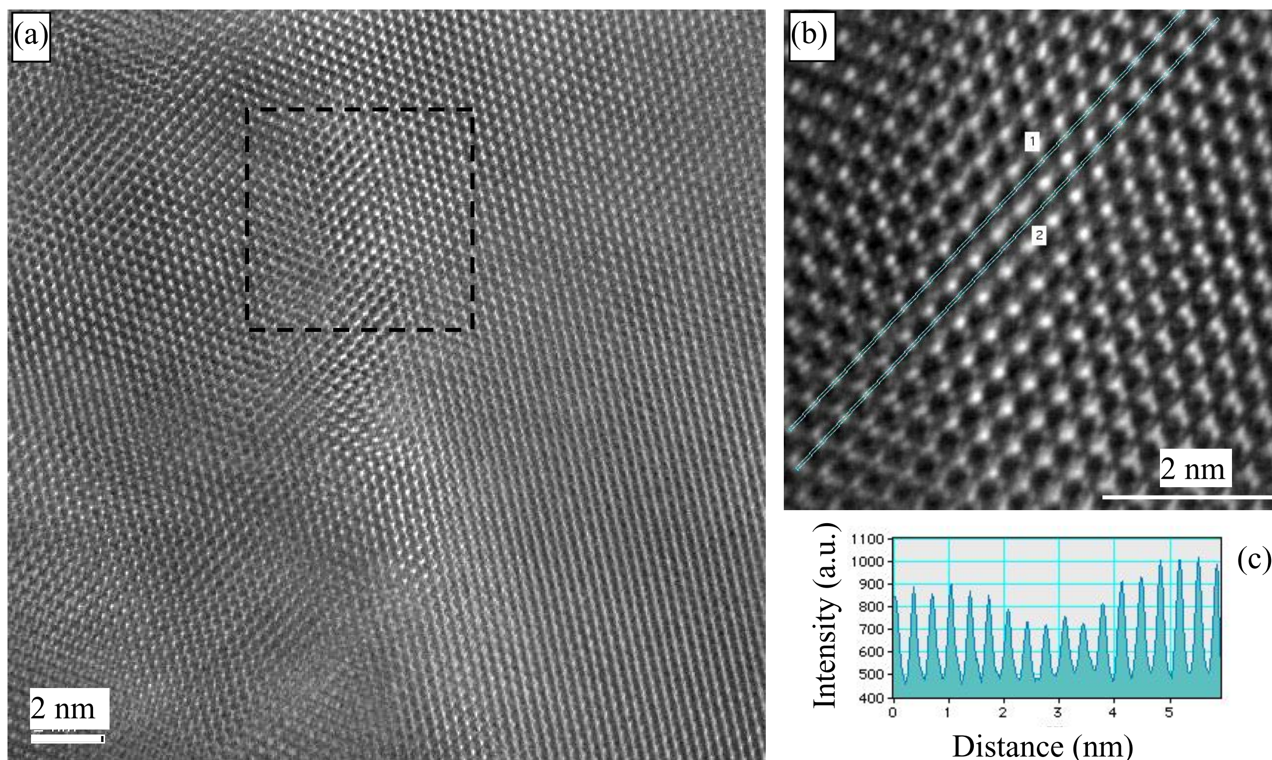

FIG. 1. (a) Thin film layer at interface in Ge-7 at.% Sn. (b) Enlargement of area indicated in (a). (c) Intensity profile marked as 1 in (b).

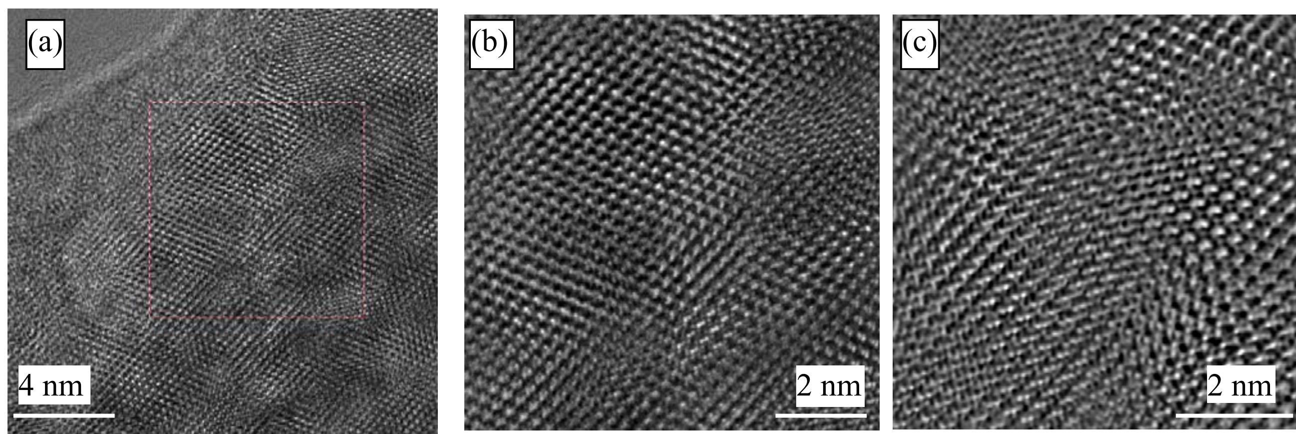

FIG.2. HREM image of interfacial region in Ge-7 at.% Sn sputtered thin film (defocus -240 nm). (b) Enlargement of area indicated in (a). (c) Exit wave reconstructed image.

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