World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:15, No:05, 2021

Study of Buried Interfaces in Fe/Si Multilayer by Hard X-Ray Emission Spectroscopy

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Abstract : To the extent of our knowledge, X-ray emission spectroscopy (XES) has been applied in the soft x-ray region (photon energy ≤ 2 keV) to study the buried layers and interfaces of stacks of nanometer-thin films. Now we extend the methodology to study the buried interfaces in the hard X-ray region (i.e., ≥ five keV). The emission spectra allow us to study the interactions between elements in the buried layers from the analysis of their valence states, thereby providing sensitive information about the physical-chemical environment of the emitting element in multilayers. We exploit the chemical sensitivity of XES to study the interfaces between Fe and Si layers in the Fe/Si multilayer from the Fe $K\beta_{2,5}$ emission spectra (7108 eV). The Fe $K\beta_5$ emission line results from the electronic transition from occupied 3d to 1s levels (i.e., valence to core transition) and is hence sensitive to the chemical state of emitting Fe atoms. The comparison of emission spectra recorded for Fe/Si multilayer with Fe and $FeSi_2$ references reveal the formation of $FeSi_2$ at the Fe-Si interfaces inside the multilayer stack. The interfacial thickness was calculated to be 1.4 ± 0.2 nm by taking into consideration the intensity of Fe atoms emitted from the interface and the Fe layer. The formation of $FeSi_2$ at the interface was further confirmed by the X-ray diffraction and X-ray photoelectron spectroscopy done on the Fe/Si multilayer. Hence, we can conclude that the XES in the hard X-ray range could be used to study multilayers and their interfaces and obtain information both qualitatively and quantitatively.

Keywords : buried interfaces, hard X-ray emission spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy
Conference Title : ICISM 2021 : International Conference on Interfaces, Surfaces and Materials
Conference Location : Berlin, Germany
Conference Dates : May 20-21, 2021