Application of Aluminum Nitride Thin Film on Biosensing of Cell Differentiation

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Abstract

The microstructural properties and functional failure of Al-N thin films metal-insulator-metal (MIM) capacitors fabricated by reactive-sputtering were studied for the application as differential biosensing of bone cell. The film properties and capacitor capability of Al-N films with and without cell culture were determined using glancing incident X-ray diffraction, leakage current density, cross-sectional transmission electron microscopy, and stress analysis as well as biocompatibility test. The as-deposited Al film has a face-center cubic structure and a low resistivity of 3.21 $\mu\Omega$ cm. With increasing nitrogen concentration of Al-N films, phase transformations are identified as fcc-Al $\rightarrow$ fcc-Al(N) $\rightarrow$ fcc-AlN $\rightarrow$ hcp-AlN. As the testing result of MIM capacitor, it was shown that the failure of the AlN MIM capacitors was caused by microvoids formed on the film after cell culture. The microvoid having occurred at the cell/AIN MIM capacitor caused it to leak out much of the current to the extent of a few microamperes even at 150 kV/cm. The formation of microvoid and low break down voltage were explained by the stress variation during the cell differentiation and proliferation. The stress induced by interaction bone cell and hcp-AIN film resulted in lattice and/or atomic displacement and distortion of AlN. It is believed that the [002] oriented AlN film is shown to perform effectively as a biosensing film to detect the cell differentiation and proliferation by MIM capacitor device. Furthermore, the biosensing film will have a potential for use in wireless technology to monitor the osseointegration in the future.