ABSTRACT

Thin nanocrystalline silicon films were grown on quartz by low pressure chemical vapor deposition (LPCVD) of Si from silane and were then oxidized to form a two-dimensional layer of Si nanocrystals embedded in SiO_2. The nominal thickness of the nanocrystals in the z-direction after oxidation varied from 2.1 to 22.1 nm. The structure and morphology of these nanostructured samples was examined by Transmission Electron Microscopy. Electron diffraction images confirmed the growth of arrays of Si nanocrystals in amorphous SiO_2 matrix. Transmission electron microscopy (TEM) observations on cross-sectional specimens revealed that the films had a columnar growth. The measured thickness deviates less than 11% from the nominal thickness of the films. The lateral size of the nanocrystals was obtained from plane view and cross sectional conventional and high resolution TEM images. The mean size was found to increase with layer thickness. In multilayer structures the characteristics of nanocrystals were the same as in the one-layer structures. The interface between nanocrystalline layers and SiO_2 showed roughness, giving rise to thin tunnel barriers of SiO_2 between adjacent Si nanocrystals. The electrical measurements showed a strong dependence of nanocrystals size and carrier mobility. The results showed that when strong confinement effects exist, carrier transport is significantly reduced due to exciton localization and Coulomb blockade effects, leading to limited current. In large sized nanocrystals, the Coulomb blockade effects do not exist and we observe carrier transport through increased current. When illuminating samples with a lamp Xe, we noted an augmentation in current as carriers increased and an almost linear I-V characteristic.