Electronic properties of Al-Nb mixed oxide as a function of their composition

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Anodic niobia has been considered as a potential substitute for anodic tantala in the capacitor industry with advantages of increased dielectric constant (~ 40- 50), and reduced oxide density (4.74 g cm^{-3}), compared with the corresponding values for tantalum oxide, (25-30) and 8.04 g cm^{-3} respectively). Low leakage current values and thermal stability under polarization are mandatory for use of anodic film as a dielectric. This is the case for anodic oxides on aluminium and tantalum but not for those on niobium. The behaviour of niobium oxide can be related to the reduced band-gap energy compared with anodic alumina or tantala, higher non-stoichiometry, giving a material with n-type semiconductor characteristics, and higher tendency to crystallize under electric field.

Sputtering-deposited alloys of valve metals, with particular emphasis on aluminium alloys, enable formation of anodic oxide layers of controlled composition, with the anodizing behaviour related to the contributions of the individual alloy components. Anodic oxide growth proceeds through co-operative transport of cations and anions, with film formation at the oxide/electrolyte and alloy/oxide interfaces. The relative migration rates of the cations determine whether the anodic oxide is single-layered or contains layers of differing compositions.

The combination of aluminium and niobium shows promise for generation of anodic oxides for capacitor applications. In order to examine further this possibility, aluminium alloys, with niobium contents up to 93 at.%, have been prepared by magnetron sputtering. The anodizing behaviour, resultant morphology and composition of the oxide, and dielectric performance were probed by Rutherford backscattering spectroscopy (RBS), transmission electron microscopy (TEM) and electrochemical impedance spectroscopy (EIS). Photocurrent Spectroscopy (PCS) was employed to reach a better understanding of electronic properties (band gap and flat band potential) of anodic films on the investigated alloys. The PCS analysis suggests the formation of "mixed oxides" behaving like n-type semiconductor or insulator depending on the Al/Nb ratio incorporated into the film. The results seems to indicate that it is possible to tailor, within some range, the electronic properties (E_g, ε_{ox}) of mixed Al-Nb oxides.