Temperature effect on Niobium Oxides and MnO_2 based structures

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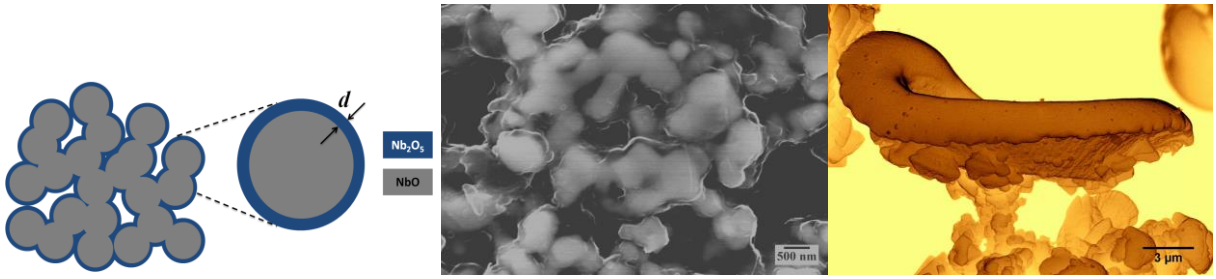
Abstract

A typical structure of a tantalum (Ta) ceramic capacitor is characterized by an anode of Ta grains with an amorphous layer of tantalum pentoxide (Ta_2O_5) around them (which is oxidized from the Ta grains), and a cathode of MnO_2 around the latter. Niobium has been reported as a cheaper alternative to tantalum, presenting potentially better properties, i.e. higher dielectric constant and lower density.
In this work, we study the effect of the temperature on niobium monoxide (NbO) pressed anodes before anodization. NbO acts as the anode. It was found that NbO/Nb_2O_5 core-shell structures are formed by oxidation activated by temperature. The thickness of the amorphous Nb_2O_5 shell increases with the temperature causing the appearance of structural colours due to optical interference in this thin layer. This is shown by SEM microscopy and reflectance spectroscopy. Because the thickness of the layer along the samples is neither homogeneous nor uniform, this work shows that heat treatments, before anodization, at temperatures higher than 300 ºC, in air, may produce an undesirable dielectric layer thus interfering negatively with a niobium based ceramic capacitor dielectric properties. This can however be an interesting process after the anodization to create a barrier that reduces the leakage current and therefore improve the electrical properties of the capacitor.
One of the final steps in the manufacturing process of a tantalum or niobium ceramic capacitor is the impregnation of a MnO_2 layer around the NbO/Nb_2O_5 structures, by pyrolysis of manganese nitrate. The nitrate is impregnated as a viscous slurry and the samples heated at different temperatures. Complex structures, resembling mushrooms shapes, were found to occur at the surface of the capacitors for the highest pyrolysis temperature. This is an important result as it gives us an upper temperature limit for pyrolysis reaction, since these types of structures negatively interfere with the adhesion of the electrical contacts during the manufacturing and therefore compromising the properties of the capacitor.

Figures



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