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Ta_2O_5 nano-crystals created by anodization

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Abstract

Nanostructures of Ta_2O_5 have a great potential in the next generation semiconductor electronics. These structures can be prepared by anodization of Ta through an Al_2O_3 template under certain conditions. Nanocrystals created in this experiment were examined by the scanning electron microscopy (SEM). The next experiment will be the creation of Ta_2O_5 nanowires.

Keywords: Ta_2O_5 nanocrystals, anodization

Introduction

Ta_2O_5 is a material of great interest for fabricating semiconductor and photonic devices. This is due to its unique properties such as high dielectric constant, low leakage current density, high index of refraction and low optical propagation losses. Its high dielectric constant and low leakage current density make it popular for a use in the next generation semiconductor electronics (Hrdy et al. 2007).

In certain electrolytes for porous alumina formation the anodic processing (under certain conditions) of a specimen, which consists of a Ta layer covered with a relatively thick Al layer, results in the formation of metal oxide nanocrystals, which are systematically self–organized in the depth of the alumina pores, as outlined in Fig 1.

Materials and methods

The anodization of 2 μm thick aluminum layer, which was sputtered on the tantalum, proceeded at 16 °C in oxalic acid and led to a creation of nanopores with size of about 50 nm. Anodization time was about 13 minutes. During anodization, the steady–state voltage is adjusted to 53 V in order to grow the film with a particular pore size and pore population density.

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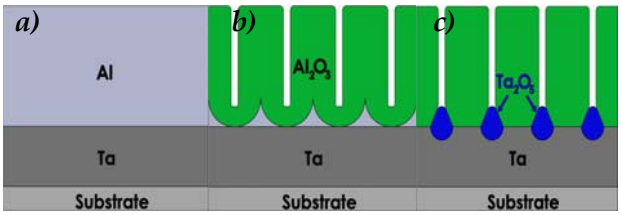

Figure 1: Schematic diagram showing the main steps for forming Ta_2O_5 nanocrystals a) a sample before anodization b) porous anodizing the Al layer down to the Ta layer c) locally anodizing the Ta layer through the pores (adapted from Mozalev et al., 2009).

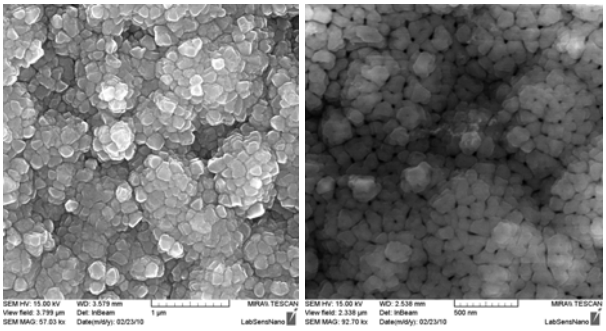

Figure 2: SEM pictures of the sample surface a) layer of aluminum before anodization b) porous alumina surface anodized in oxalic acid at 53 V at 16 °C. Anodization time was 13 minutes. The scale bar is 1μm (left) respectively 500 nm (right).

Results and Discussion

Nanocrystals of the tantalum oxide (hillocks) begin to grow when the alumina barrier layer reaches the tantalum layer (Fig 1b); since then the alumina barrier layer is dissolved at the alumina/tantalum interface by the growing of the tantalum oxide nanocrystals.

The sample was examined by the scanning electron microscopy (SEM) Tescan FE Mira II LMU in high vacuum mode 1.2 x 10^{-2} Pa and voltage 15 kV. A created structure is shown in Fig 3.

Conclusion

Nanocrystals of tantalum oxide have been created via anodization of an aluminum layer and following dissolution of the porous template. The next step is going to be a continuation of the method mentioned above and the creation of Ta_2O_5 nanowires.

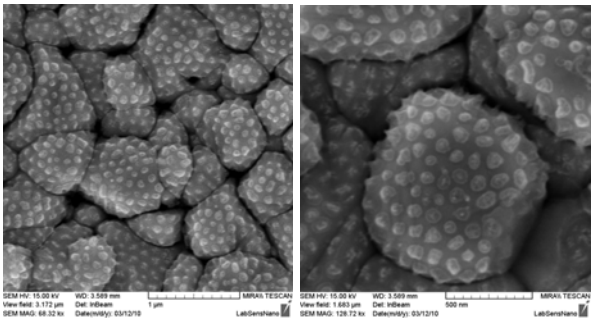

Figure 3: SEM pictures of Ta_2O_5 nanocrystals on crystals of Ta (after dissolution of the alumina template), the scale bar is 1μm (left) respectively 500 nm (right) .

Acknowledgement

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