Niobium oxide nanocolumns formed via anodic alumina with modulated pore diameters

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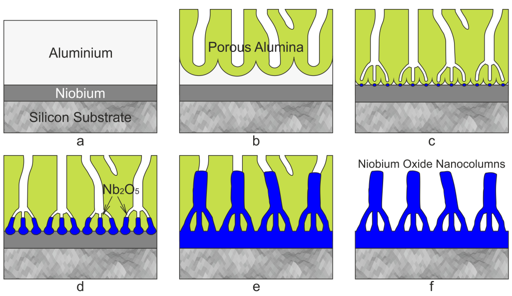
Porous anodic alumina matrixes (AAM) are characterized by uniform cylindrical pores which can be used for templated synthesis of arrays of various nanostructures. Manipulation of the size, position and regularity of the pores AAM allow forming conceptually new structures on its base with wide range of applications.

This paper presents the results of forming of metal oxide nanocolumns with variable diameters by high-voltage reanodization via AAM with modulated pore diameters. The main stages of film growth, with the relation between the film layers thick, are depicted in Fig. 1.

Single silicon wafer with magnetron-sputtered layers of 300 nm Nb and 1200 nm Al was used as substrate (Fig. 1, a). Regular AAM with modulated pore diameters was formed by sequential anodization of the Al in 0.2 mol·d^{-3} $C_4H_6O_6$ at 180 V and in 0.4 mol·d^{-3} $H_2C_2O_4$at 37 V (Fig. 1, b, c). Array of niobium oxide nanocolumns was formed by high-voltage reanodization of the Nb layer via AAM in the mixed solution of 0.5 mol·d^{-3} H_3BO_3 and 0.05 mol·d^{-3} $Na_2B_4O_7$ in potentiodynamic mode at 400 V (Fig. 1, d, e). Further AAM was selective dissolved in 50 % H_3PO_4 (Fig. 1, f). As a result, array of Nb_2O_5 nanocolumns high 800 nm was formed on the solid layer NbO_2 thin 450 nm on Si-substrate (Fig. 2).

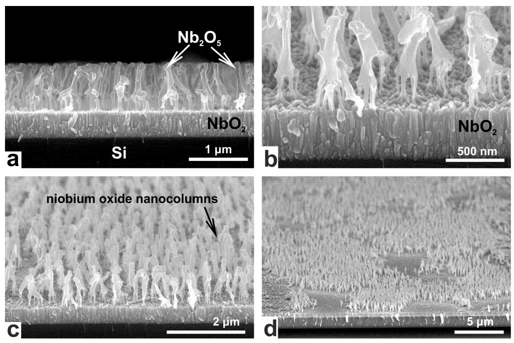
The nanocolumns consist of upper layer high 630 nm and diameter 100 nm in the base of which are located 4-7 columns high 170 nm and diameter 25 nm. Nanocolumns have an unordered structure because anodization of aluminum was carried out in one step without preliminary structuring of the surface. The additional ordering of the Al layer by the two-step anodization will make possible to form regular AAM and produce high-ordered nanocolumns on their basis.

So, the developed technique based on the combination of the methods of formation of porous anodic alumina with modulated pore diameters and high-voltage reanodization of Nb underlayer via the AAM. The formed structures can be used as photonic crystals, autoemission elements and functional applications of promising devices of nano- and optoelectronics.



(a) sputter-deposition of Nb-Al bilayer on SiO2/Si substrate, (b) growth of porous alumina film, (c) anodization of the Nb underlayer through the alumina nanopores, (d) growth of thin niobium oxide nanocolumns in the alumina pores, (e) growth of thick niobium oxide nanocolumns in the alumina pores, (f) dissolution of the alumina ("alumina-free" sample).

Fig. 1 the main phases of the films formation process .jpg



Samples formed by sequentional anodization at 180 V in $C_4H_6O_6$ and at 37 V in $H_2C_2O_4$, then reanodization at 400 V in H_3BO_3. All images of the nanostructures were obtained after dissolution of the alumina ("alumina-free" samples).

Fig. 2 scanning electron microscope images of arrays of niobium oxide nanocolumns on si-substrate .jpg