EXPRESS - CONTROL OF THIN FILM TECHNOLOGIES BY ANODIZATION SPECTROSCOPY METHOD

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Abstract— **It is the new promising method of obtaining the information about the state of a surface of a solid body, thin and multilayer structures. An idea of the method consists in reading and analyzing the relations U(t), dU/dt(t), dU/dt(U) on an electrical cell when anodizing an investigated object. By these relation it is possible to control the presence of impurities in the metal on the path of the anodization front, a structure and characteristics of the object being oxidized as well as of an oxide which is being formed during anodizing, the change in composition of the oxide layer, the thickness and composition of metallic and dielectric layers being a part of the layers boundaries.**

It is known that anodic oxidization of the metals by the constant current method, thickening of the oxide layer is followed by the growth of voltage on the electrolytic cell. The growth rate of the oxide layers thickness and the voltage change on the oxide layer depend on a molecular mass of the oxide, oxide density, valency of oxidation reaction, the chemical efficiency, etc, which determined creation of the anodization spectroscopy method for multilayer thin film structures. It is the new promising method of obtaining the information about the state of a surface of a solid body, thin and multilayer structures. An idea of the method consists in reading and analyzing the relations U(t), dU/dt(t), dU/dt(U) on an electrical cell when anodizing an investigated object. By these relation it is possible to control the presence of impurities in the metal on the path of the anodization front, a structure and characteristics of the object being oxidized as well as of an oxide which is being formed during anodizing, the change in composition of the oxide layer, the thickness and composition of metallic and dielectric layers being a part of the layers boundaries. The method has a high depth resolution (0,5nm - 0.01nm). As to the accuracy it does not yield to such methods layer by analysis as Auger-spectroscopy, the secondary electronic emission, etc. but have some advantages: there is no broadening of the concentration profile, analysis is made several minutes, the required equipment is several orders cheaper. Initially the method of anodization spectroscopy was used for the express-control of superconductive niobium films and tunnel structures based on niobium and aluminium. During the work in the given field we have created the methods for investigation films morphology, impurities in films, interdiffusion between layers, a degree of non-stoichoimetry of films oxides. Unique equipment for anodizing and anodization spectroscopy was developed. Investigations have shown that the method can be successfully used not only in the cryoelectronic microcircuit technology but in other fields of science and technology as well as in studying a more extended number of characteristics of different surfaces, film and multilayered structures. In our opinion, it is very promising in the field of creating oxides layers, both dense and porous, simple and modernized.

The anodization spectroscopy techniques permit to create the total express-control system for microcircuits thin film technology. It can include control of substrate roughness, film thickness, oxide layers, size deviations, deposition field, iron etching investigation, oxydized condition and other.

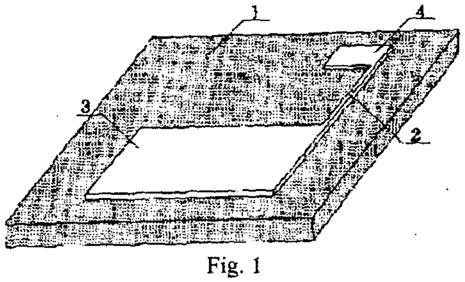

Fig. 1

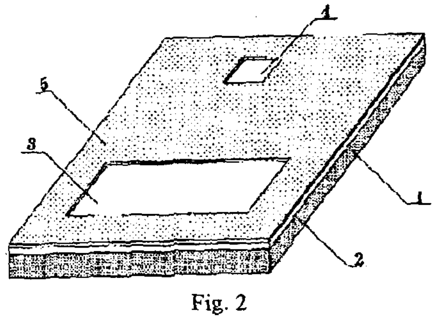

Fig. 2

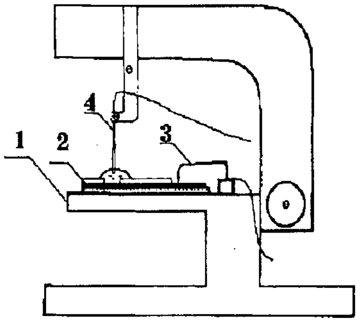

Fig. 3

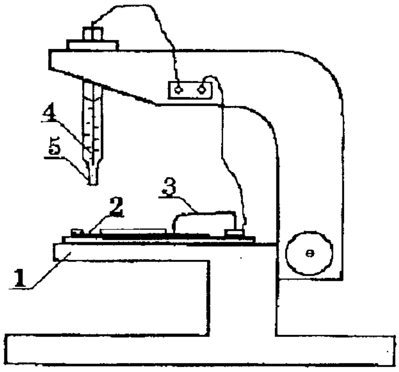

Fig. 4

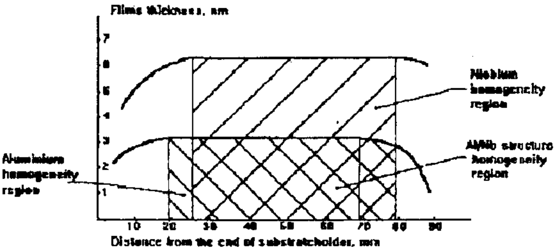

Fig. 5 The technique for determining the homogeneity region for Nb/Al structure.

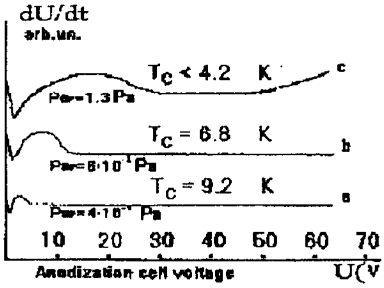

Fig. 6 Anodization profiles of niobium films deposited by magnetron at various conditions; a-P_{ar}=0.4Pa; b-P_{ar}=0.6Pa; c-P_{ar}=1.3Pa.

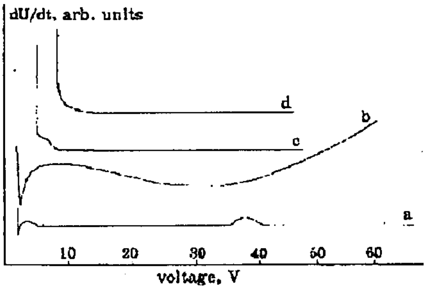

Fig. 7 Anodization profiles of niobium films contaminated during fabrication.

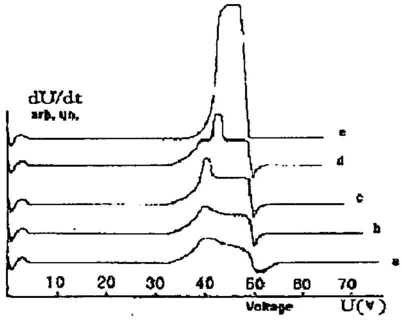

Fig. 8 Anodization profiles of multilayered structures based on niobium and aluminium

a- Nb/AlO_x-Al/Nb, electron beam deposition, thermal Oxidation;

b- Nb/AlO_x-Al/Nb, magnetron deposition, thermal oxidation;

c- Nb/AlO_x-Al/Nb, magnetron deposition, ion oxidation;

d- Nb/Al-AlO_x-Al/Nb, magnetron deposition, thermal oxidation;

e- Nb/AlO_x-/Nb, electron beam evaporation of all layers

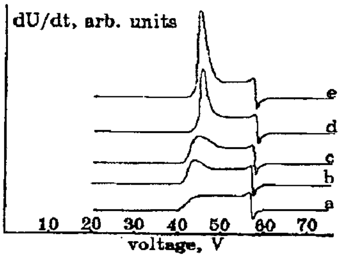

Fig. 10 Anodization profiles of multilayered structure.

a) Nb/Al/Nb

b) Nb/AlO_x-Al/Nb, thermal oxidation, t_{ok}=15 min;

c) Nb/AlO_x-Al/Nb, thermal oxidation, t_{ok}=60 min;

d) Nb/AlO_x-Al/Nb, oxidation at magnetron plasma;

e) Nb/AlO_x-Al/Nb, combined oxidation.

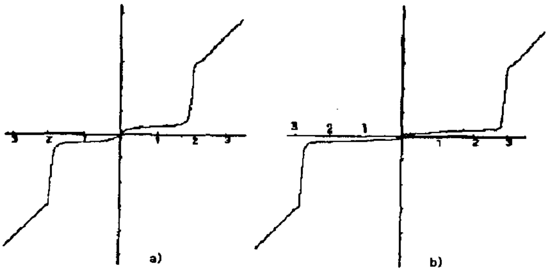

Fig. 9 Volt-ampere characteristics of Josephson junctions Nb/AlO_x -Al/Nb deposited by magnetron:a) $\upsilon_{Nb}=0.9$ nm/s;b) $\upsilon_{Nb}=5$ nm/s.

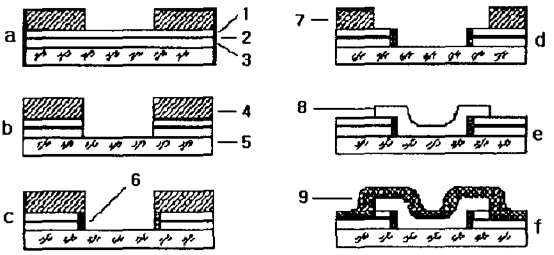

Fig. 11 Stages of fabrication of thin-film SQUID Nb/AlO_x O'Al/Nb by Tap-process; 1-niobium film Nb_2(upper electrode); 2-barrier layer (AlO_x-Al); 3-niobium film Nb_1 (bottom electrode); 4-photoresist; 5-substrate; 6-Nb_2O_5 film (anodic isolation); 7-photoresist; 8-niobium film Nb_3 (wring layer); 9-niobium anodic oxide (formation of Josephson contact area by anodization).

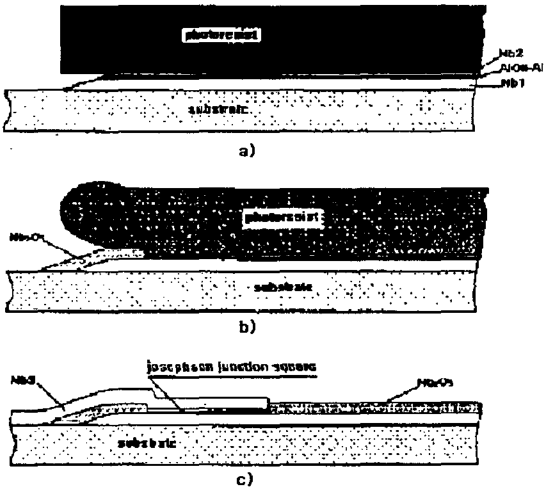

Fig. 12 Cross-section of thin-film structure during the fabrication of Josephson junctions by TAP process: a-after etching of three-layer structure; b-after anodizing of edge; c-after fabrication.

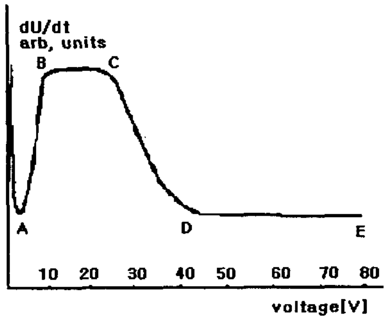

Fig. 13 The anodization profile of the structure Nb/AlO_x-Al/Nb edge using photoresist mask.

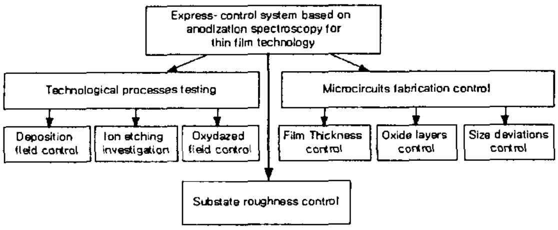

Fig. 14 Express-control system.