ACOUSTO-ELECTRONIC SUPERCONDUCTING SWITCH

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ABSTRACT

The results of design and fabrication of cryotron (T_c = 90K) switch on the $Yba_2Cu_3O_{7-\delta}$ compounds base controlled by surface acoustic waves (SAW) for frequency range from 50 to 500 MHz are presented. The switch is optimized for the minimal switching time and can be used in memory or switch schemes.

INTRODUCTION

In 1935 Casimir-Janken and de Hass[1] created cryogen switch or cryotron controlled by means of magnetic field. Thin film cryotron ensures switching time ~ 2 ns and is formed by two crossing stripes (divided by insulating layer), manufactured from materials with different temperature values for critical magnetic field.

It is known that superconductivity is ensured by electron-phonon interaction leading to the electrons interaction and formation of related pairs of electrons. It is supposed to generate acoustic waves in superconductive material $Yba_2Cu_3O_{7-\delta}$ to destroy electron-phonon interaction and in such a way to switch the superconductor to the conductivity mode.

DESIGN

The main problem in the $Yba_2Cu_3O_{7-\delta}$ cryotron design is to achieve the most effective generation of SAW and to ensure the minim of switching time. To generate SAW we used interdigital surface wave transducer (ISWT) with inner pulse linear frequency modulation,

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which converts electrical signal into elastic acoustic waves. The period of ISWT is changing along the transducer in accordance with frequency change during the pulse duration. One part of the transducer for repper frequency range, another one for lower frequency range. The signals with linear frequency modulation (LFM)[2] of inner part of pulse are the constant amplitude pulse, which contain linear changing in time oscillation in certain frequency range. From the condition of parameteres matching of input electric circuit and electrical parametes of ISWT we defined the converter aperature W and from the condition of equality of acoustic channel impedance and electrical oscillator impedance the optimal quantity of transducer grid stripes is defined[3] .

In practice the most important are SAW-distribution in the surface layer of piezocrystal with a thickness of the wave's length. It should be mentioned that the chosen superconductor $YBa_2Cu_3O_{7-\delta}$ doesn't have the necessary piezoelectric parameters to convert electrical signal into acoustic one. For this purpose we used additional material simultaneously with $YBa_2Cu_3O_{7-\delta}$, in which effective SAW exciting can be achieved. As the result, comparing the parameters of materials for SAW devices we chose GaAs with orientation 110, 001[4]. For matching materials with different acoustic impedances one can use a quarter wave layers like those for optical lenses and VHF transmission line [2, 5].

PRODUCTION

To produce a monolithic switch we used an epitaxial procedure of AlGaAs layer (~ 7 μm) growth on GaAs substrate above which a quarter wave layer GaAs of orientation 110, 011 was epitaxially grown. Longitudinal and transversal contacts of Cu-Cr were deposit on the epitaxial layer GaAs by means of reverse photolitography technique and than were activate in Pd-salts solution. The $YBa_2Cu_3O_{7-\delta}$ layer was deposit onto GaAs epitaxial layer in a such a way, that its thickness together with that of the GaAs layer is about a wave length and its transversal acoustic impedance is about the impedance of GaAs[4, 6]. Transversal contacts are placed along the b-axis of $YBa_2Cu_3O_{7-\delta}$-layer and coincide with the direction of SAW propagation but the longitudinal ones – along the **c**-axis of $YBa_2Cu_3O_{7-\delta}$-layer and are perpendicular to the direction of SAW propagation. The resulting structure is fixed at the $YBa_2Cu_3O_{7-\delta}$ side by means of the K-18 compound to the lead base. At the same time the K-18 compound serves as an absorber of reflected acoustic waves from the border of the "$YBa_2Cu_3O_{7-\delta}$ layer - lead base" interface.

At the final stage the AlGaAs layer was etched and the Cr-Al ISWT was formed on the high quality surface of GaAs epitaxial layer by means of reverse photolitography, in which the direction of SAW propagation is perpendicular to the **c**-axis of $YBa_2Cu_3O_{7-\delta}$-layer. Dimension of the structure is 1,5×1,5 mm.

CONSTRUCTION

The structure of the switch with lead base was put in the case from "brokerit–9". The measurements were performed at the temperature of liquid nitrogen. To avoid the influence of cavitation effect in liquid nitrogen on the results of measurements the sample of switch was put into Cu-tube and was independently fixed from outside. The amplitude of electrical signal was equal 4V and the ISWT transmission coefficient on the first maximum of fre-