Краткие сообщения ОИЯИ №4 [30]-88   *JINR Rapid Communications No.4 [30]-88*
УДК 537.312 + 541.15 + 548.539

THE EMISSION CHARACTERISTICS OF $Y_1 Ba_2Cu_3O_{7-\delta}$ CATHODE

S.A.Korenev

The results are presented of experimental investigation of the electron beam in diode with cathode on the base of $Y_1 Ba_2Cu_3O_{7-\delta}$. After corresponding cathode training, the cathode made from $Y_1 Ba_2Cu_3O_{7-\delta}$ material may be practicable of stable current electron beam yeild. It is shown experimentally that at the voltage of diode of about 100÷÷300 kV there exists an evident possibility of forming the electron beams with the current density of 70 A ÷ 380 A/cm^2. The motion velicity of cathode plasma in the direction of anode for this material of a cathode amounts to $(1 \div 3) \cdot 10^6$ cm/s.

The investigation has been performed at the Scientifical-Methodical Division, JINR.

Эмиссионные характеристики катода из $Y_1 Ba_2Cu_3 O_{7-\delta}$

С.А.Коренев

Приводятся результаты экспериментального исследования формирования электронных пучков в диоде с катодом со взрывной эмиссией на основе $Y_1 Ba_2Cu_3 O_{7-\delta}$. После тренировки катода, изготовленного из $Y_1 Ba_2Cu_3O_{7-\delta}$, можно осуществлять стабильный токоотбор пучка электронов. Экспериментально показано, что при напряжении на диоде 100÷300 кВ можно формировать электронные пучки с плотностью тока ~70÷380 А/см^2. Скорость движения катодной плазмы в сторону анода для этого материала катода составляет $\sim (1 \div 3) \cdot 10^6$ см/с.

Работа выполнена в Общеинститутском научно-методическом отделении ОИЯИ.

In high temperature superconductor research, attention is paid to the emission characteristics of superconductors /1/ .

In this rapid communication the experimental results of the electron emission from the $Y_1Ba_2Cu_3O_{7-\delta}$ superconductor cathode working in explosion regime are given.

The experiments have been performed on high-current electron beam source /2/. The electron source consists of a high-voltage Arkadiev — Marx pulse generator (peak voltage ~100-300 kV, pulse duration 300-1000 ns) and vacuum diode. The anode was made from stainless steel grid having transmission coefficient ~ 0.6. The cylindrical $Y_1Ba_2Cu_3O_{7-\delta}$ cathode fixed on a liquid nitrogen cooled support has diameter 6 mm and the tip radius 3 mm.

The emission characteristics of 3 cathodes (having resistivities ρ ~ 2 $\Omega \cdot$cm; 10^{-1} $\Omega \cdot$ cm; $2.5 \cdot 10^{-2}$ $\Omega \cdot$ cm) have been investigated. The cathode temperature prior to impulse starting was measured by a Cu-constantan thermocouple. The apparatus vacuum pressure was $5 \cdot 10^{-5}$ Tor. The electron beam current was registered by an integrating Rogovski transformer and a Faraday cup; the voltage, by high resistance pulse attenuator.

In fig. 1 the voltage-current characteristics (v.c.ch.) of diodes having the plasma initiation regime temperature T_1 ~ 300 K (fig.1a) and T_2 ~ 79 K (fig. 1b) are displayed. The cathode-anode distance is 1 cm. As one can see analysing the v.c.ch., the current yield of diode does not depend on the cathode resistivity at both temperatures T_1 and T_2. The experimental results could be explained as following. Due to the cathode surface geometrical microinhomogeneities the explosive cathode plasma is formed under the high voltage pulse influence. The cathode plasma here is the electron emitter. As can be seen in fig. 2a, where the part of cathode is shown, the cathode has a large

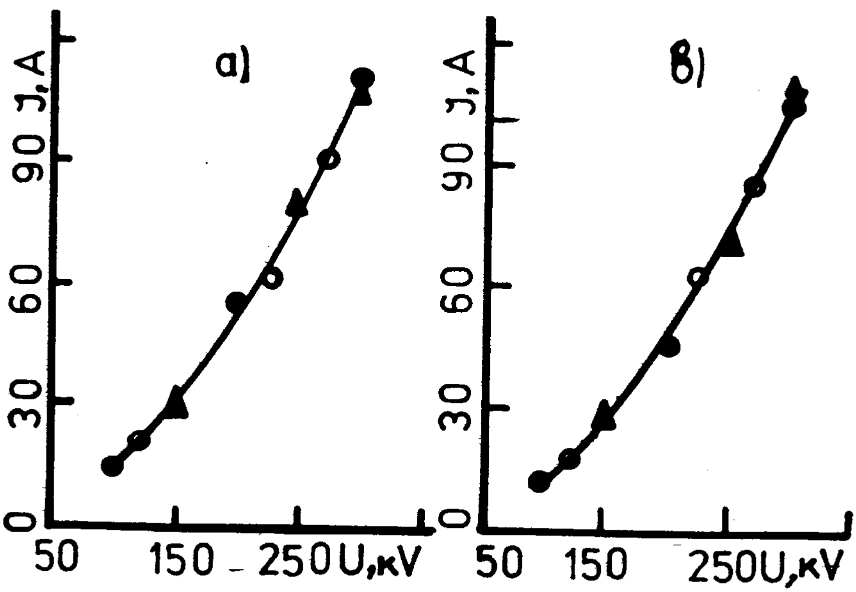

Fig. 1. Voltage-current characteristics of electron source diode with cathode made of $Y_1Ba_2Cu_3O_{7-\delta}$ for t_1 ~ 300 K (a) and t_2 ~ 79 K (b) and for: o – ρ ~ 2.5×10^{-2} $\Omega \cdot$*cm;* ● – ρ ~ 10^{-1} $\Omega \cdot$*cm;* ▲ – ρ ~ 2 $\Omega \cdot$*cm.*

amount of different inhomogeneities on its surface, causing effects of local electric field shielding in the primary flare region, so the electron current oscillates. However, after dozens of pulses (the cathode training) these oscillations disappear, as a result of melting of the cathode surface by cathode plasma. The SEM picture of such a cathode surface (after 10 pulses, 300 keV, 300 ns) is presented in fig. 2b.

As can be seen in fig. 1, the v.c.ch. of the electron current yield corresponds to the Child-Langmuir law.

The velocity of cathode plasma may be calculated from the commutation characteristics of diode. We have calculated $V_{c.p.} \sim 3\times 10^6$ cm/s for material resistivity $\rho \sim 2.5\cdot 10^{-2} \div 10^{-1}$ $\Omega\cdot$ cm and $V_{c.p.} \sim 10^6$ cm/s for $\rho \sim 2$ $\Omega\cdot$cm. In comparison with the other cathode materials, of carbon fiber, for example, having $V_{c.p.c.f.} \sim \sim 5\cdot 10^6$ cm/s, an $Y_1Ba_2Cu_3O_{7-\delta}$ cathode permits us to enlarge the electron pulse beam duration approximatily 1.7 ÷ 5 times. This pulse enlarging permits one to construct planar source working at microsecond regime, having such a cathode with anode-cathode distance $\sim$ 1 cm and pulse duration ~ 1 μs .

Conclusion

1. After corresponding cathode training, the cathode made from $Y_1Ba_2Cu_3O_{7-\delta}$ material may be used for construction of high current pulsed electron beam sources giving stable and homogeneous electron beam pulses. The electron current yield satisfies the Child-Langmuir law.

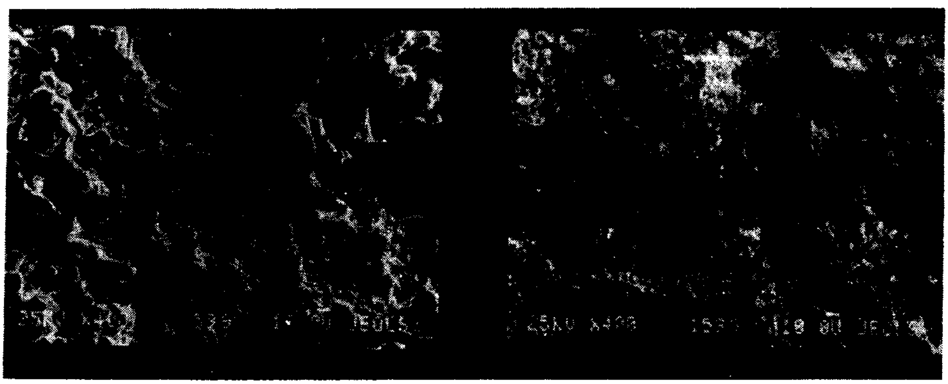

Fig. 2. SEM picture of $Y_1Ba_2Cu_3O_{7-\delta}$ cathode surface prior to (a) and after (b) cathode training (10 pulses, $U \sim 300$ kV, $\tau_p \sim 300$ ns).

2. The electron beam of microsecond duration can be formed in the planar diode, which is possible due to the use of $Y_1Ba_2Cu_3O_{7-\delta}$ cathode.

I would like to express my gratitude to D.Valentovic, O.G.Zamolodchikov, S.P.Kobeleva, O.K.Smirnova for giving me kindly their superconductive $Y_1Ba_2Cu_3O_{7-\delta}$ ceramic material for construction of the above discussed cathodes.

References

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Received on April 26, 1988.