METAL ALLOY THERMIONIC CATHODE WITH HIGH EMISSION DENSITY

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Introduction

The electron gun of ion source and its thermionic cathode must meat some serious requirements stemming from the ion source operation principals. The most difficult to fulfil is the cathode effectiveness requisite. In order to achieve high enough ion beam current we have toinsure that presumes the necessity of maintaining not only high electron current in the drift space but also its density. The most easy way for this purpose to use thermionic cathode with high emission density.

Cathode material

So the necessity of selecting the right cathode material or synthesizing a new one appropriate for solving or alleviating this difficulty rest with cathode technologist. To put is simply we have to use a cathode that has
1) low enough work function to keep the working temperature as low as possible to minimize evaporation;
2) low evaporation rate.
The cathode material usually contains some electropositive elements which spread itself over the cathode surface as a monoatomic polarised layer consistituting a double electrical layer, which reduces the work function. By such elements are used mostly Barium, Lanthanum, thorium.
To keep there evaporation rate low this elements are used as chemical compounds with high energy of formation. This commands are teh oxides, salts and intermetallic compounds.
We have worked out an alternative way of ting up the electropositive "cathode" elements by employing its metallic alloy. One of the most suitable choices in this direction could be the metal alloy materials from the alloy systems of iridium with rare earth (RE) elements. From those systems two metals are more efficient: lanthanum and cerium because of relatively low work function (2.6-2.8eV) of some its alloys with iridium and low rate of evaporation of lanthanum or cerium atoms from these alloys. We have determined for energy of formation of the IrCe compound quite high value: 2.5 eV on one cerium atom. Actually the evaporation rate of cerium (and also lanthanum) from these alloy with iridium is lower then that from pure RE mtals by a factor of 10*E5-10*E6. The relatively low work function of said alloys is an evidence of the existence on it surface of a monatomic RE element layer. The emission density up to 100 A/cm2 can be achieved quite easy.

Cathodes units

1. The miniature directly heated cathode mounted on a tungsten filament base brazed to the cathode body. This filament is used at the same time also as a heater. The Joule energy from the heater flows down to the cathode body by the thermoconductance mechanism. That mean that the radiated part of the heater power is not used. The electrical resistance of the filament in this sort of a unit must be kept at a value nearly equal to 1 Om if the power efficiency is to be maintained reasonably high and the temperature of the filament not

exceeding the value 2100-2200K when it stays reliable. This peculiarity brings the resulting values of the current to very high values when we try to employ the unit with big cathode. So the tolerable size of the directly heated cathode is equal to 0.1-1mm, when the heater current is in the range from 0.5 to 10 A.

2. For bigger cathodes can be used cathode units, deferring by its relatively higher electrical resistance. They are comprised the cathode body connected to a spiral tungsten filament with itself could not be used as a safe support due to its form. Therefore the cathode body has to be supported by a Molybdenum or Tantalum sleeve, which is also serves as a mean to pick some of the heat radiated by the filament which is in strictly direct heater unit is almost totally lost. The drawback of this type of cathode unit is the same: too low a heater resistance and to high a value for the heater current. The size of such cathodes may be in the range from 1 mm to 30 mm. The bigger than that alloy cathodes were not manufactured and used till now. The heater current for such cathodes varies from 10 A to some hundred A.

3. The complex cathode unit in which there is not only the main cathode body, but also an auxiliary inner cathode also can be used with the alloy type cathode structures. In these units the heating of the cathode body is achieved by bombardment of the main cathode with accelerated electrons emitted by the auxiliary cathode. In this case the resistance of the unit may be quite high because it is the resistance of a vacuum clearance.

The auxiliary cathode must be kept at its operating temperature with the special heater which can be simply the direct heater due to little size of the cathode. The most common value for the cathode voltage put between the main and the auxiliary cathodes is several hundred Volts, and the electron bombardment current is significantly less than 1 A for the cathode sizes involved in p. 2.

It is easy understood that to little auxiliary cathodes of little size operating with low bombardment current we must apply higher values of intercathode voltage. It must be kept in mind that the complex cathode units have one serious drawback, namely, its lack of stability, which arises from the existence in it of a positive type feedback. This feedback arises from the radiated heat connection between the cathodes and it can bring the dynamic electrical resistance of the unit to zero or a negative value.

When we reach the point with the negative resistance the cathode unite can be "blown up" by the sudden rise of the bombardment current. This type of instability is encountered when the auxiliary cathode is operated at regime in which the emission is restricted by temperature but not by the electron space charge. From this arises a requirement for the auxiliary cathode to be used only in regime on "deep" space charge which in turn required the use of high effective cathodes. Because of this we usually employ in the auxiliary cathode the same alloy material.

All this cathode units have got the same set up sizes (fig 1).

Guns

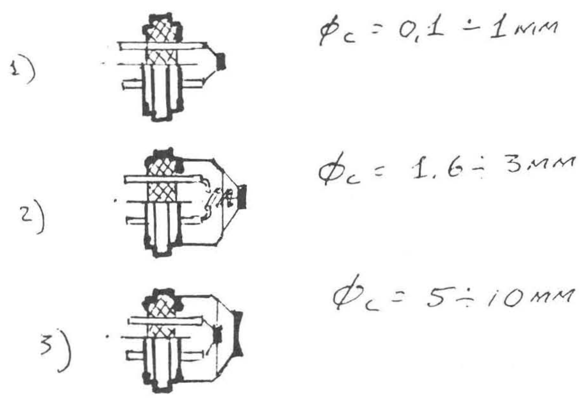
We have developed two types of e-guns for research applications in the different kinds of the e-devises. The main principals of design is :

1. cathode supporting system can be acceptable for all types of the cathodes units , which have been discussed in the previews chapter,

2. all elements of the e-gun, namely, cathode, focusing electrode, anode can be easy change.

The e- gun design is shown on the fig.2

The first type of the e- gun is for location on the vacuum body of the e- devises on the standard conflet flange. The another type of the guns for internal location into the vacuum vessel of the e-devise. This type of the e-gun can be used as the fist e-gun in the complex of HVe-gun. This e-gun have been used in Russian Electron Beam Ion Trap and in Cryogenic Electron Beam Ion Source "Krion-C".



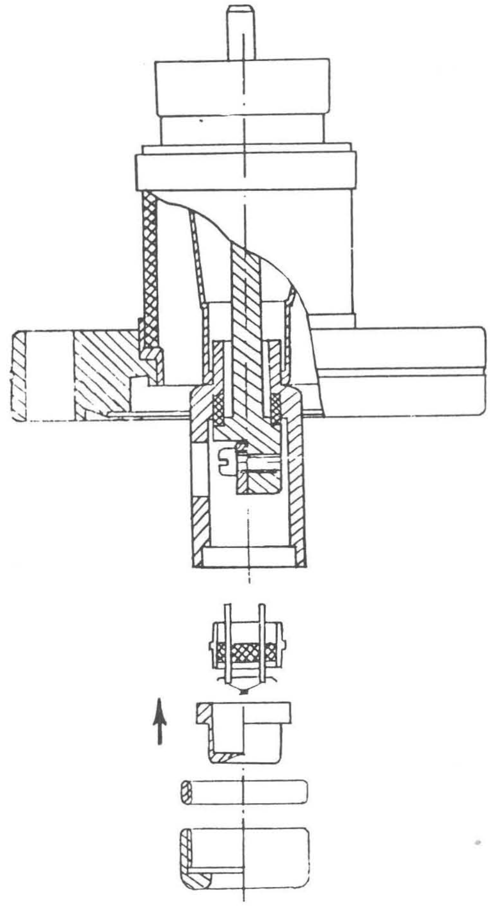


fig.1.