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Modern technologies of X-ray systems for control of electronic components

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Abstract. Some issues of technology and design of modern X-ray devices for quality control of microelectronic devices are considered. The functional capabilities of both types of technologies are compared. The design of the Russian microfocus X-ray tube – a key element of the devices for control, is described.

1. Introduction

In recent years, the range of tasks in the electronics industry with the help of X-ray systems significantly expanded. X-ray systems for the control of possible defects in the various components of microelectronics and quality of PCB for new technologies intensively developed [1]. The main element of such a system is a microfocus X-ray tube. It defines its scope of application. Two classes of microfocus tubes are used: opened tube with constant maintenance of vacuum and closed tube.

2. Materials and methods

The functional diagram of the X-ray system is shown in figure 1.

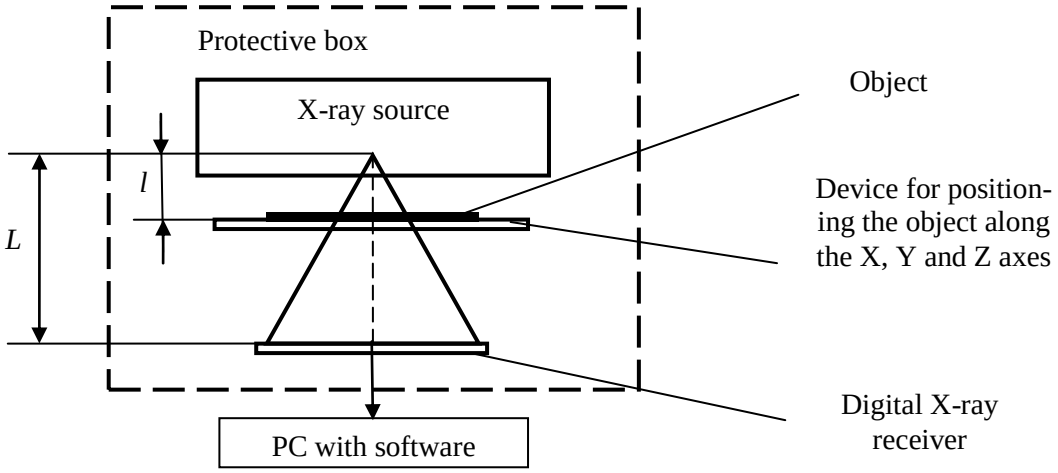


Figure 1. The functional diagram of the X-ray system: *L* – distance from the X-ray source to the image receiver, *l* – distance from the X-ray source to the object.

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The source, object, object positioning device and receiver are located in a special box with leaded walls (X-ray protection box), which does not allow x-ray radiation to go beyond it.

In foreign X-ray systems, three types of X-ray tubes are used. Open tubes – with a rod anode and closed tubes - of two modifications: with massive and rod anodes (figure 2).

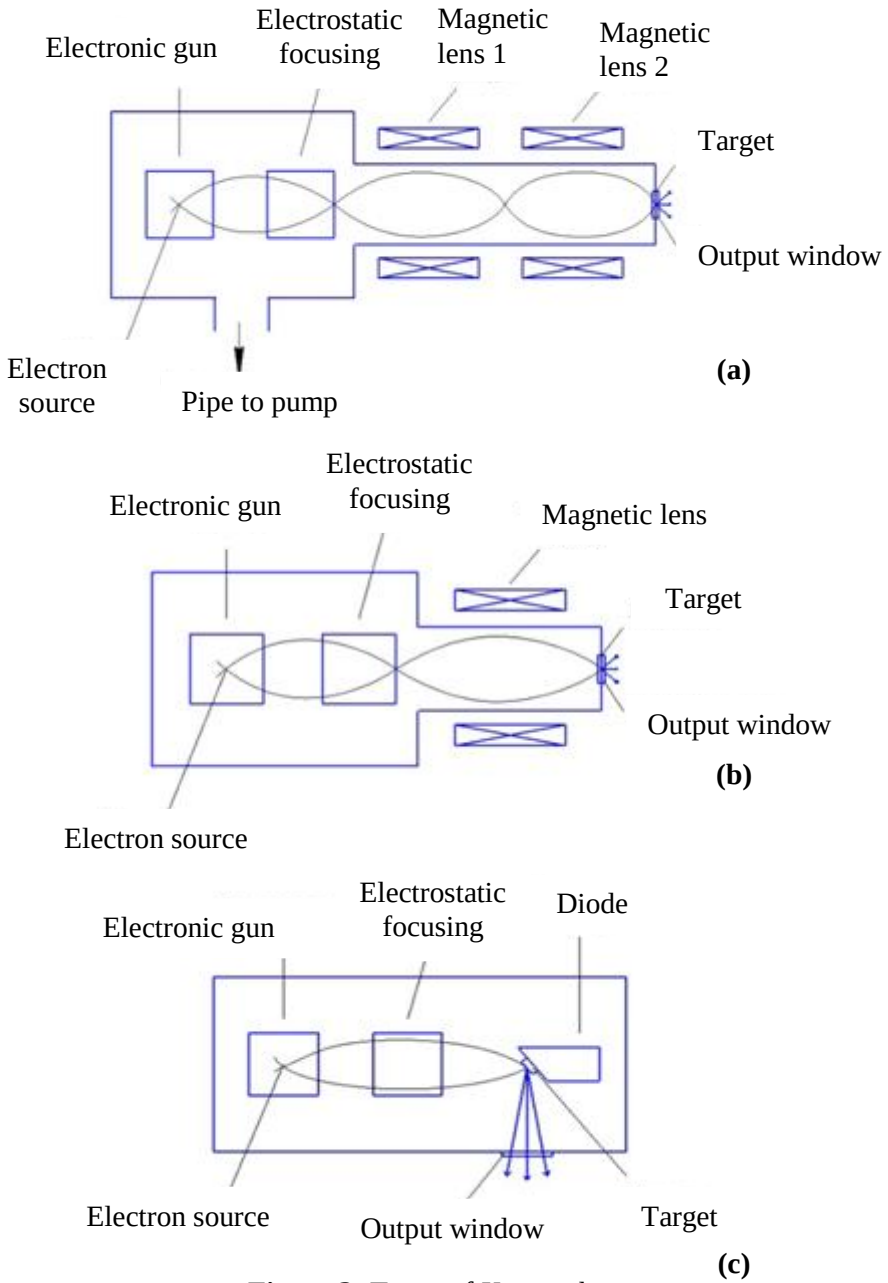


Figure 2. Types of X-ray tubes.

In Russia, such X-ray systems are not commercially available, but X-ray tubes for the development of the discussed systems have already been developed. Figure 3 shows a closed microfocus X-ray tube of the family BS for voltage of 150 kV with rog anode.

3. Analysis of technology

Each of the two technologies for developing X-ray systems has its advantages and disadvantages.

X-ray systems on open tubes allow for thin objects to detect defects less than 1 μm due to a more perfect focusing system and the choice of anode design. Operation of the X-ray tube at maximum modes is possible, since we can replace the cathode and the target of the anode.

However, X-ray systems on open tubes have a whole set of significant disadvantages compared to X-ray systems on closed tubes:

- large dimensions, weight and complexity of the construction, associated with the use of a cermet insulator, which is designed for the full working voltage of the tube and vacuum-tight mechanical collapsible tubing connections with replaceable units (cathode and anode);
- in the tube there is an integral constructive element - a specialized vacuum post;
- the tube must be trained after the replacement of the nodes, which imposes additional requirements on the generator of the power supply and alignment of the electron-optical system;
- increase in the size of the focal spot is possible due to mechanical vibrations of the vacuum post;
- high price.

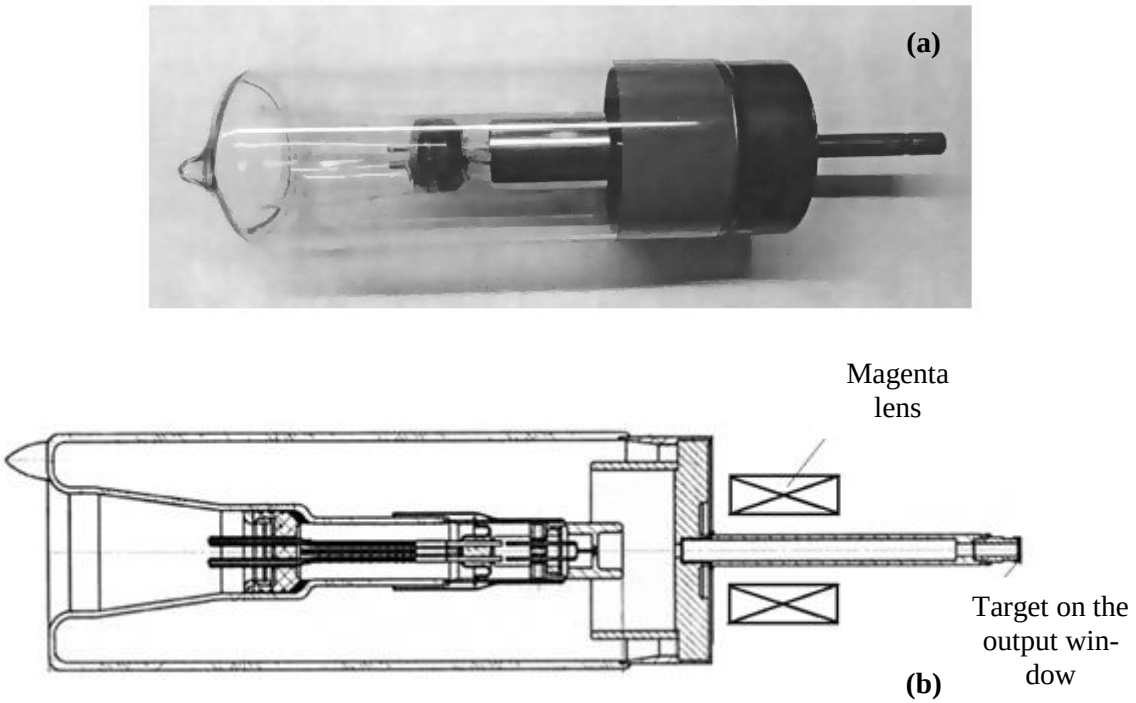


Figure 3. Russian microfocus X-ray tube of the BS series with rog anode: (**a**) – appearance of the X-ray tube BS-16 (III); (**b**) – design of the X-ray tube BS-16 (III).

These shortcomings are absent in closed-tube X-ray systems. They significantly outperform open-tube systems based on a whole set of other consumer properties.

For example, replacing a closed tube (in case of its failure) is technologically simpler than replacing the nodes in an open tube:

- alignment of the electron-optical system and high-voltage training is not needed
- replacement of the tube takes less time than the replacement of the anode or cathode in the open tube;
- the power consumption is much lower.

Particularly effective tubes with rog anode. They are stable in work and durable. The negative effect on their electrical strength of the electrons scattered on the target is eliminated by the absence of an electric field in the rog anode.

4. Conclusion

X-ray inspection systems built on both technologies are in demand in the electronics industry. Systems on closed tubes with massive anodes are effective for controlling large and dense objects, where it is sufficient to detect defects of 5 μm or more in size

Systems based on closed tubes with rog anode should be chosen to detect defects up to 2.5 μm in size. The most advanced systems based on open tubes with anode allow detecting defects less than 1 μm. However, the higher the resolution of the system, the lower such consumer properties as price, dimensions, weight, and also the translucent capability due to the reduction of the maximum value of the voltage on the X-ray tube.

Multifocus open X-ray tubes are promising in the development of X-ray systems. They have modes of different power to control dense objects or medium-density objects, as well as a high-resolution mode for controlling nanostructures. The mode switches in the process control objects. However, in many cases, a closed tube with an anode is more practical. The size of the focal spot can be adjusted by means of a magnetic or electromagnetic lens.

Acknowledgment

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References

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