

Point MEMS X-ray source

The discovery of X-rays by Wilhelm Roentgen has revolutionized the World. Almost everyone on their own skin could notice its usefulness during various types of injuries, bone fractures or sprains, during epidemiological examination or visits to the dentist. One of the advantages of X-rays is the fact that they penetrate through soft tissues, but are absorbed by materials of higher density (higher atomic mass). X-rays are not useful only for medical applications, but also for inspection of defects and imperfections of industrial products, mechanical structures or electronic systems, that are not visible to the naked eye. In addition, X-ray radiation is used for studying the composition of materials (so-called X-ray spectroscopy).

100 years ago X-rays were produced by powerful lamps, in which the filament heated to a high temperature emitted electrons. Electrons accelerated to a very high velocity reached the anode and generated radiation. What is very important, the lamps had to be pumped out to high vacuum and sealed so that their properties would not deteriorate over time - electrons would be scattered on the gas particles, ionize them, and they would lose energy themselves. In addition, in the presence of air the filament would burn out quickly.

In recent years, a lot of work has been carried out towards miniaturization of X-ray tubes, their size has been significantly reduced, in some solutions the thermal sources of electrons have been replaced by a field-emission source, which resulted in a reduction of the power consumption. However, for a long time it was impossible to cope with the problem of creating a sufficiently high and stable vacuum inside the miniature devices. This led to the fact that although most of the components of the source were made using sophisticated micro- and nanoengineering techniques, but the whole structure was sealed in classic glass, ceramic or metal casings using techniques developed decades ago.

The breakthrough occurred in recent years, when the first miniature vacuum pumps were developed at the Wrocław University of Technology. They were made by microengineering techniques (MEMS technology - Micro-Electro-Mechanical System), and enabled generation of high vacuum inside microsystems.

The aim of this project is to explore the possibility of developing a complete miniature X-ray source using MEMS techniques. Such a source will contain a field-emission cathode with a layer of carbon nanotubes, a system of electrodes responsible for emission of electrons and beam focusing, a specially designed anode/target, on which X-ray radiation is generated and an integrated vacuum micropump. The whole device will be made of silicon and glass, it will be smaller than the matchbox, it will weigh several grams, and thanks to that such sources could be in the future mass-produced and applied not only in specialist laboratories.