MEMS TRANSMISSION ELECTRON MICROSCOPE

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This article presents a concept and fabrication process of a miniature, integrated on-chip transmission electron microscope in "illuminating" (Fig 1a) and "scanning" modes. Both versions of the microscope are made of silicon and glass substrates, which are micromachined by the use of microengineering processes. These MEMS devices consist of an electron gun with field-emission CNT cathode, an electron-optic column, a very thin silicon nitride membrane located in the center of an anode and a high vacuum micropump. All parts of the microscope were modeled, made and tested separately and prepared for integration on one chip. The silicon electrodes and glass spacers were connected together with the use of the anodic bonding process. The last bonding process was made in vacuum conditions ensuring that the vacuum inside the instrument will be sufficient to start the high vacuum micropump operation.

Technology and working of the electron gun, the electron-optics column, and the anode with Si_3N_4 membrane were tested. Demonstrator of MEMS microscope in illuminating mode was integrated on-chip and tested in air. First, the electron-optic column was evacuated to a high vacuum of 10^{-5} mbar by the micropump. Then the rest of the electrodes were supplied with high voltages and the cathodoluminescence of a phosphor deposited on the outside of the Si_3N_4 membrane was observed (Fig. 1b). The voltage of the focusing electrode was altered and the change in the shape of the visible light spot was observed, which confirmed the correct operation of the entire system. The miniature MEMS transmission electron microscope in illuminating mode isn't suitable to make good quality images for samples located on the membrane, but it'll be a good instrument to make cathodoluminescence measurements of the biological samples. The fabricated device is able to work with voltages up to 5 kV, without electrical breakdown.

The scanning system of the miniature MEMS transmission electron microscope is now under tests and the first results are promising. The samples lying on the outer surface of the membrane are scanned with an electron beam controlled by means of an octopole electrode (Fig. 1c) and a dedicated electronic system. Detectors in the form of silicon electrodes are used to collect signal what is synchronized with the scanning beam. The dedicated computer program creates the image. During initial tests, the resolution of such a system was estimated as better than 1 μm. The next step is the integration of the scanning system with the demonstrator of the MEMS transmission electron microscope.

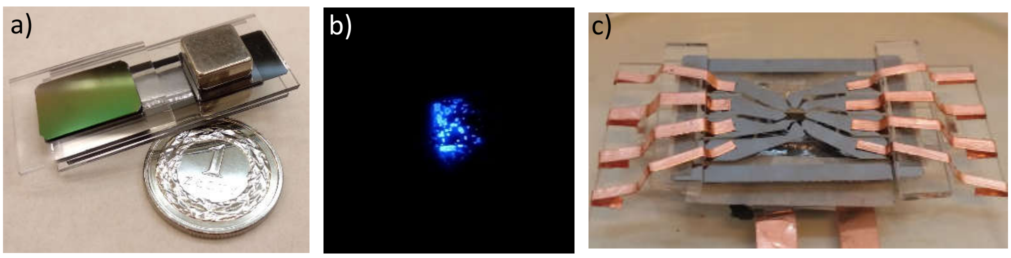

Fig 1. a) Demonstrator of MEMS TEM, b) cathodoluminescence of the phosphor deposited on the silicon nitride membrane, c)octopole electrode with electrical connectors

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