

# **Technology and properties of microsystems fabricated by 3D and 4D printing techniques**

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3D and 4D printing are emerging research topics in the field of microsystems technology. Significant advances in the development of new functional materials, multi-material technologies, and tools for controlling the additive manufacturing process will likely enable the gradual replacement of traditional microsystem manufacturing with 3D printing technologies. The main research objective of the work was to conduct a comprehensive study of 3D inkjet printed technology for microsystems incorporating micromechanical structures, and to demonstrate the usefulness of this technique by fabricating and studying the properties of exemplary microsystems made by 3D/4D inkjet printing. This goal was achieved by developing two exemplary printed microsystems along with the electronic devices necessary for their operation. These are:

- a) Miniature mechanical-to-electrical energy converter (so-called energy harvester) - intended for use in so-called "zero-energy" devices, which, thanks to 3D and 4D printing techniques, have the potential to realize the concept of the Internet of Things (IoT) or, further, the Internet of Everything (IoE).
- b) Microsystem for studying seed growth in Earth's gravity and microgravity - a microsystem, fabricated using 4D printing technology, for studying seed growth in gravity and microgravity conditions, designed with the idea of using it in space missions in low Earth orbit (LEO).

Both examples are consistent with the trend of recent research related to the use of microsystems - extracting electric energy from the environment and studying the effects of microgravity on living organisms. Based on the research conducted and the analysis of the literature, it can be concluded that 3D and 4D printing are techniques that can be used in microsystems technology.

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