HIGH VACUUM MEMS DEVICES – MINIATURIZED ANALYTICAL INSTRUMENTS

Michał Krysztof, Tomasz Grzebyk, Piotr Szyszka, Paweł Urbański, Marcin Białas, Jakub Jendryka, Jan Sobków, Jan Dziuban
Wroclaw University of Science and Technology, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw
E-mail of corresponding author: michal.krysztof@pwr.edu.pl

ABSTRACT

Modern scientific tools such as electron microscopes, X-ray machines, and mass spectrometers all rely on very strong vacuum conditions to work properly. Traditionally, creating such a vacuum requires large equipment and complex pumping systems. These setups are expensive, bulky, and difficult to miniaturize, which limits their use outside specialized laboratories.

Recent progress in microtechnology offers a completely new approach. Instead of using large external systems, scientists can now create and maintain a vacuum inside tiny devices, similar in size to a few millimetres. At Wroclaw University of Science and Technology, researchers have developed a miniature vacuum pump that can be integrated directly into microdevices [1]. This tiny pump can generate extremely low pressure without the need for external equipment.

Thanks to this breakthrough, it is now possible to build very small and fully integrated vacuum-based devices. Examples include miniature X-ray sources [2], compact gas analysers [3], and small mass spectrometers [4] and miniaturized scanning electron microscopes [5]. These devices combine vacuum technology, electronics, and advanced materials into a single sealed structure, making them more robust, portable, and energy-efficient than traditional systems.

This new approach represents a major shift in how vacuum technology can be used. Instead of large, stationary installations, we can now design small, independent devices tailored to specific applications. Such systems could find use in space missions, environmental monitoring, medical diagnostics, and many other fields where size, mobility, and efficiency are important.

Overall, these developments open the door to a new generation of compact scientific instruments that can operate outside traditional laboratory environments, bringing advanced measurement capabilities closer to real-world applications.

References

[1] Grzebyk, T., Górecka-Drzazga, A., Dziuban, J. A. Sens. Actuators, A, 208 (2014) 113–119.
[2] Urbański, P., Grzebyk, T. J. Microelectromech. Syst., 33(5) (2024) 508–510.
[3] Szyszka, P., Stambulskyi, K., Grzebyk, T. EUROSENSORS XXXVII 2025-09-07 - 2025-09-10 Wroclaw (2025) 104–105.
[4] Szyszka, P., et al. Sens. Actuators, B, 411 (2024) 135712.
[5] Białas, M., Grzebyk, T., Krysztof, M., Górecka-Drzazga, A. Ultramicroscopy, 244 (2023) 113653.