doi:10.1017/S143192762200126X
Microsc. Microanal. 28 (Suppl 1), 2022

A New Tool for Automation of Focused Ion Beam Bitmap Milling of Two-and Three-Dimensional Micro and Nanostructures.

Jairo Narro[1] and Rosa Diaz[2]

[1.] Department of Bioengineering, University of Engineering and Technology, Lima, Peru.
[2.] Birck Nanotechnology Center, Purdue University, West Lafayette, IN, United States.

Focused ion beam (FIB) microscopes are widely used for the fabrication of micro- and nanostructures with high precision and control [1]. Compared to other nano-manufacturing technologies, such as optical/electron-beam lithography and nanoimprint lithography, FIB proves to be a powerful nanofabrication tool, especially for complex 3D nanostructures [1, 2]. The development of structures at the micro and nanometer scale with great control is important for the semiconductor industry when fabricating optoelectronic devices or micro electromechanical devices, among other examples [2]. Additionally, FIBs can be used in the biomedical field to develop biosensors and point-of-care diagnostic devices [3].

Currently, bitmap files can be used to store the information of the nano- or microstructure design and milling parameters in 3D. The grayscale value of each pixel determines the dwell time, while the pixel density and the ion beam current determine the overlap ratio [4]. Another way to generate patterns is by designing a 3D CAD model and then converting it to a stream file [3, 5]. Depending on the complexity of the structure, the generation of bitmap files can be arduous and time-consuming. In addition, poorly selected processing parameters, as well as the effects of redeposition and variable sputtered yield, can lead to considerable deviations from the ideal structure [6]. Therefore, it is important to develop software tools that calculate and control processing parameters and automate this part of the FIB milling process.

In this work, we present a graphical user interface developed in python that facilitates the generation of bitmap files for patterns or architectures of electronic devices. With this interface, the user can define the shape and dimensions of the micro- or nanostructure (Figure 1). Depending on the profile function, the optimum value of the maximum dwell time can be defined, and a suitable grayscale can be generated for 3D structures (Figure 2). A second window visualizes the cross-section view of the structure. The patterns generated in the interface can be saved as a 24-bit bitmap file and then imported into the FIB system.

This tool enables automation of the FIB process to fabricate structures with higher processing efficiency and accuracy. Finally, the parameters defined with the interface can be optimized later to compensate for errors and deviations between the ideal and fabricated structure by modifying the grayscale values of the generated bitmap file. This can be done by using computational methods and simulation models that include the effects of redeposition and variable sputtered yield [6, 7]. Combining these models with the developed interface would result in a more powerful tool whose effectiveness can be evaluated in future experiments.

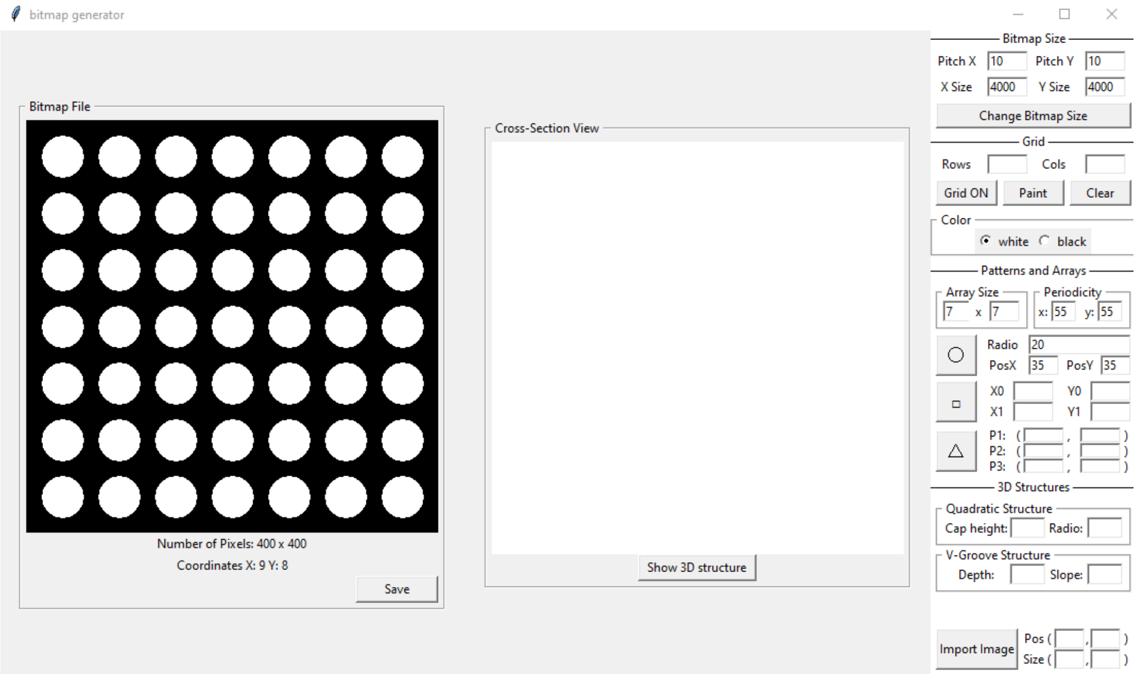

Figure 1. Nanohole array generated with the Interface. The milling area is 4um x 4um, with 7x7 nanoholes of 400 nm diameter and 550 nm spacing.

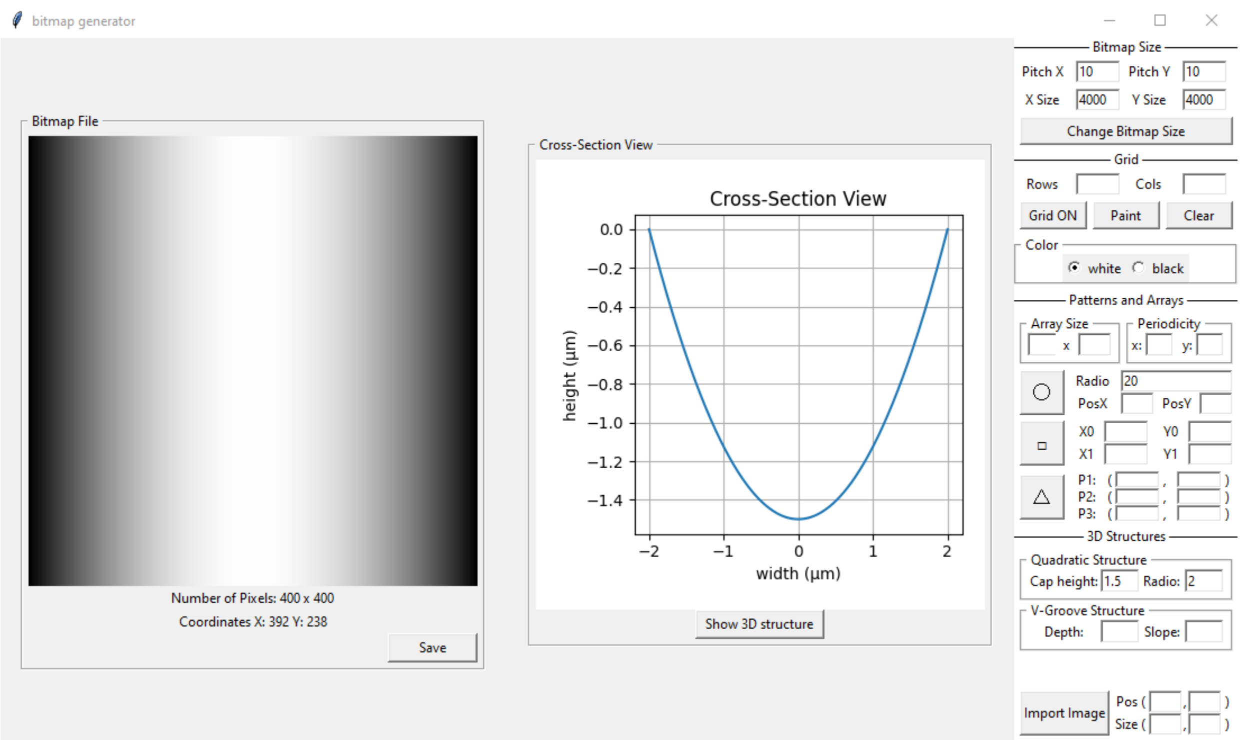

Figure 2. Bitmap generated for a quadratic microstructure and its corresponding profile.

https://doi.org/10.1017/S143192762200126X Published online by Cambridge University Press

References:

[1] A. A. Tseng, J. Micromech. Microeng. **14** (2004), p. 15. doi: 10.1088/0960-1317/14/4/R01
[2] P. Li et al., Nanoscale **13** (2021), p. 1529. doi: 10.1039/D0NR07539F
[3] D. De Felicis et al., Micron **101** (2017), p. 8. doi: 10.1016/j.micron.2017.05.005
[4] X. Chen et al., SN Appl. Sci. **2** (2020), p. 758. doi: 10.1007/s42452-020-2456-2
[5] G. Lalev et al., Journal of Engineering Manufacture **222** (2008), p. 67. doi: 10.1243/09544054JEM864.
[6] T. Han et al., 2021 IEEE 34th International Conference on Micro Electro Mechanical Systems (MEMS), pp. 662. doi: 10.1109/MEMS51782.2021.9375344.
[7] H.-B. Kim et al., Nanotechnology **18** (2007), p. 245303. doi: 10.1088/0957-4484/18/24/245303