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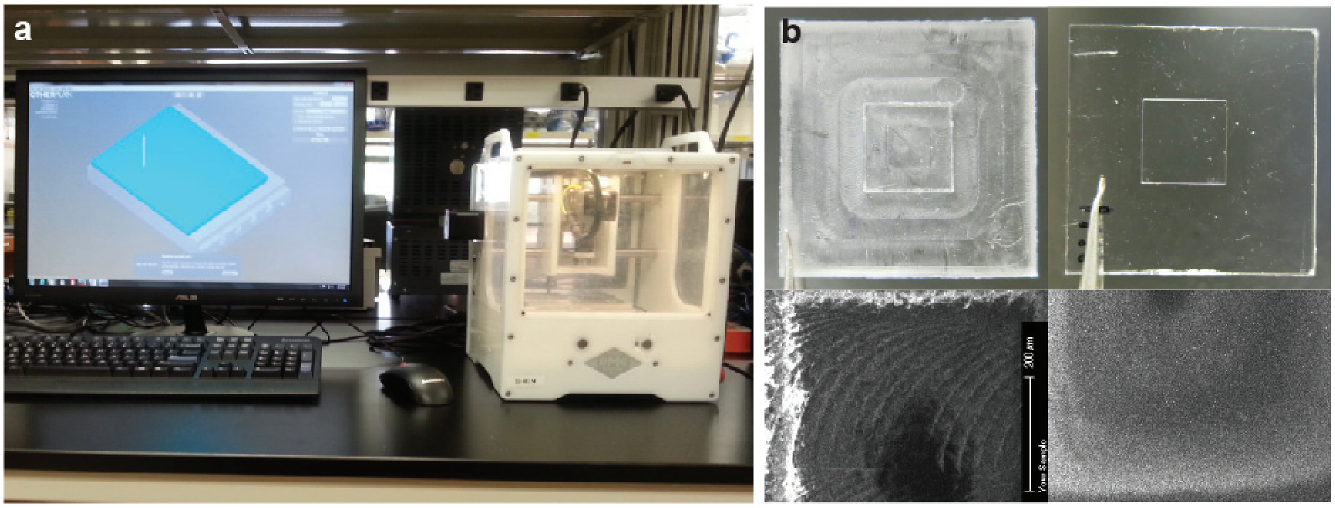
PRESS RELEASE

A cost-effective micromilling platform for rapid prototyping of microdevices

January 2017 — New desktop milling platforms as an economical, user-friendly alternative to conventional microfabrication techniques for biomedical lab-on-a-chip and organ-on-a-chip applications.



An economical, user-friendly desktop milling platform for biomedical microdevice fabrication. (a) Othermill V2 and its software interface. (b) Mechanical and chemical polishing improves surface roughness and optical transparency of milled polycarbonate (left: milled surface; right: mechanically and chemically polished; top: gross optical quality; bottom: scanning electron microscopy of the surface)

A research team from the Department of Biomedical Engineering at the University of Southern California (USC) in Los Angeles, CA has characterized the machining capabilities of a low-cost desktop computer numerically controlled (CNC) mill for producing lab-on-a-chip and organ-on-a-chip devices for research and medical applications. The manufacturing of these microdevices usually requires the integration of multi-scale geometrical features and topological finishes, and oftentimes materials with special physical and chemical properties that are not compatible with typical microfabrication techniques. Micromilling has many desirable characteristics including a wide selection of working materials and capacity for rapid prototyping with accuracy and precision. However, the high cost of micromilling machinery and the technically-demanding operations have been major obstacles for its adoption in microdevice productions, particularly in small research laboratories with limited resources and funding. Lately, a new generation of inexpensive entry-level desktop mills has emerged, featuring small form-factors and intuitive user interface while maintaining high precision and accuracy. Their potential in making microdevices, however, has not been well-tested. With an entry-level desktop mill, the Othermill V2, the USC team quantitatively characterized the machining accuracy and precision, as well as the surface roughness and optical transparency of milled plastic samples fabricated using the milling platform, and demonstrated the manufacturing of a herringbone microfluidic mixer with feature sizes from a hundred micrometers to several centimeters. This communication appears in the December 2016 issue of the journal *TECHNOLOGY*.

Rapid prototyping is among the fastest growing areas in industry in recent years, and has shown great potential in testing new ideas and creating tools and platforms. As a subtractive method, micromilling is complementary to other additive technologies such as 3-D printing, but with much more flexible material choices, and higher precision and accuracy than regular 3-D printing. "With the drive of the consumer market and the rate of technical advances, more user-friendly desktop mills with higher specifications will likely become available at similar or even lower cost in the near future. This will greatly lower the technical barriers of the micromilling technology, expand its accessibility to the biomedical research communities, and accelerate the technical innovations and scientific discoveries in biomedicine", says Professor Keyue Shen, Ph.D., the Principle Investigator on the paper.

One of the challenging characteristics of micromilling is the surface roughness of the finished devices. Machining leaves trochoidal marks on finished surfaces due to the revolving motion of the milling tools as they remove material from a substrate. As microdevices for lab-on-a-chip and organ-on-a-chip applications operate at the microscale, these surface artifacts can adversely affect the device functions, such as microfluidic laminar flow patterns, or the adhesion, alignment and distribution of living cells growing on them. Additionally, the optical transparency of the device, which is critical for microscopic observations, may be compromised. In this work, the researchers investigated both mechanical and chemical polishing methods to reduce surface roughness and improve optical clarity in polycarbonate, a biocompatible plastic widely-adopted in biomedical devices. Significant improvement of the two surface properties was achieved, with optical transparency matching that of untouched areas, demonstrating micromilling as an attractive and feasible option for manufacturing microdevices for biomedical research. "It is remarkable that two simple polishing techniques can reduce the imperfections of micromilled plastic surfaces at the micrometer and nanometer scales, respectively", says Daniel Yen, the lead author of the paper, "the integration and automation of these polishing techniques in these milling platforms will be needed for microdevices with more complicated geometries and surface topologies".

Additional co-author of this communication is Yuta Ando. All three authors are from the Laboratory for Integrative Biosystems Engineering at the University of Southern California. At present, the team from USC is further investigating the milling capabilities of this machine using different thermoplastics and potential alternative smoothing techniques to achieve optimal surface roughness and optical quality for finished devices; Additionally, this technology is being applied to create microdevices for several research projects being conducted by other group members of this laboratory, and by the collaborating laboratories at USC.

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