3D printer to aid the visually impaired students in their educational endeavors

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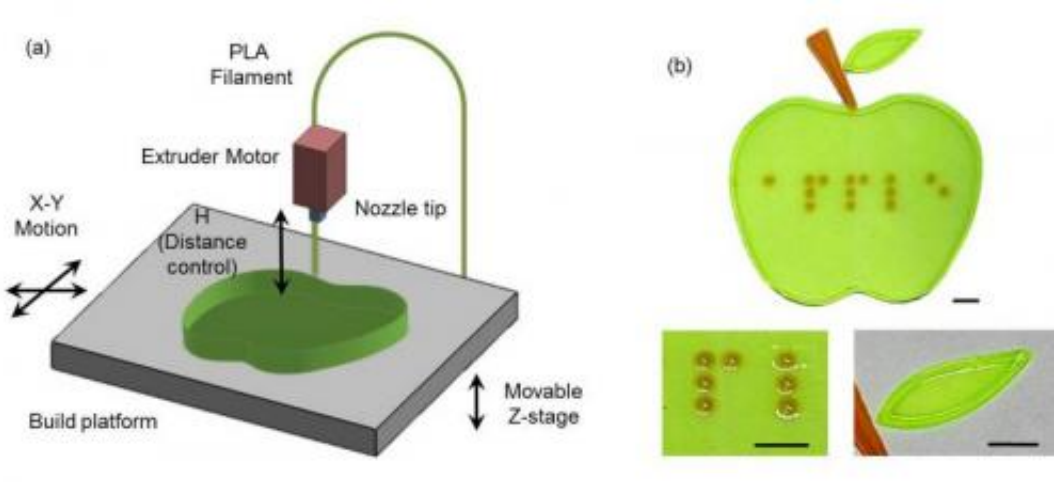
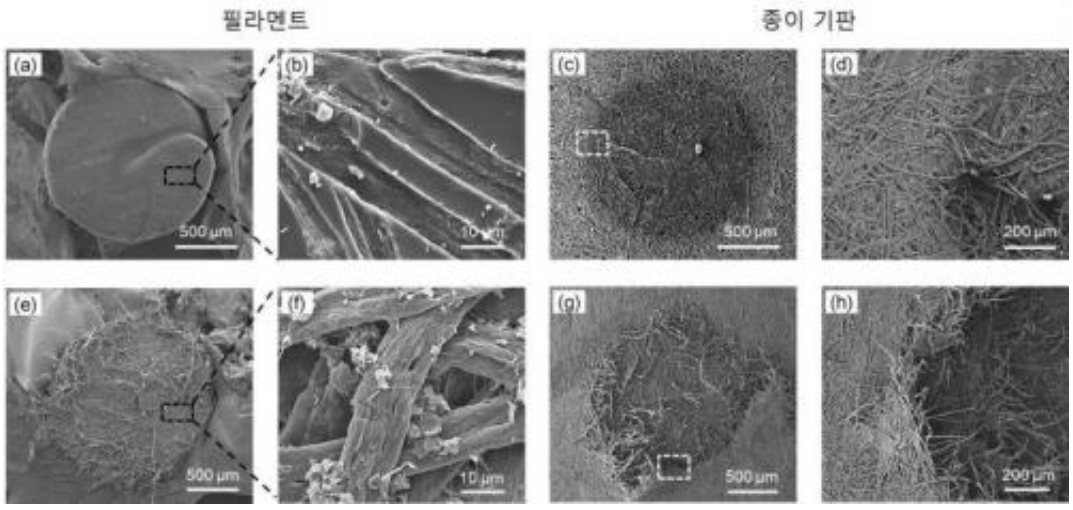


This is a diagram showing FDM 3D printing equipment (a) and a shape of 3D tactile structure (an apple) made by the printing technology and an image of tactile patterns of an apple in the standard braille (b). Credit: ©KIST

Braille is a tactile writing system, which is commonly used by the visually impaired and partially sighted. With the recent development of braille printers, written materials in braille has greatly helped the visually impaired and partially sighted individuals but, this is not to say that there are still many remaining problems such as books that are immobile due to their size and volume as well as durability. Moreover, there are other problems such as not enough books, materials, works, and data for such individuals.

New technology has been developed to make tactile objects with ease thanks to the convergence technology of 3D printing and 3D thermal reflow treatment, which can be denoted as the revolution in manufacturing technology. Using the technology, not only braille books, but also braille picture books and teaching materials can be made with greater flexibility in color, height and size. It is also harmless to human body since it does not require UV coating or harmful chemical treatment.

The research team led by Dr Myoung-Woon Moon at the Korea Institute of Science and Technology developed a new method by converging 3D printing and 3D surface thermal reflow treatment techniques to produce touchable objects with detailed lines and curves. The research team used thermal reflow treatment on the surface to enhance durability and adhesiveness. The newly developed technique has been filed for patent registration domestically. In addition, this research was accepted for publication by the journal of *RSC Advances* with the title, "3D Printed Tactile Pattern Formation on Paper with Termal Reflow Method."



(a~d) Images of backside of braille detached from paper boards; (a, b) Before thermal treatment, it does not have full adhesiveness between filament and paper so it is easily detached by external impact and the image shows only pressed

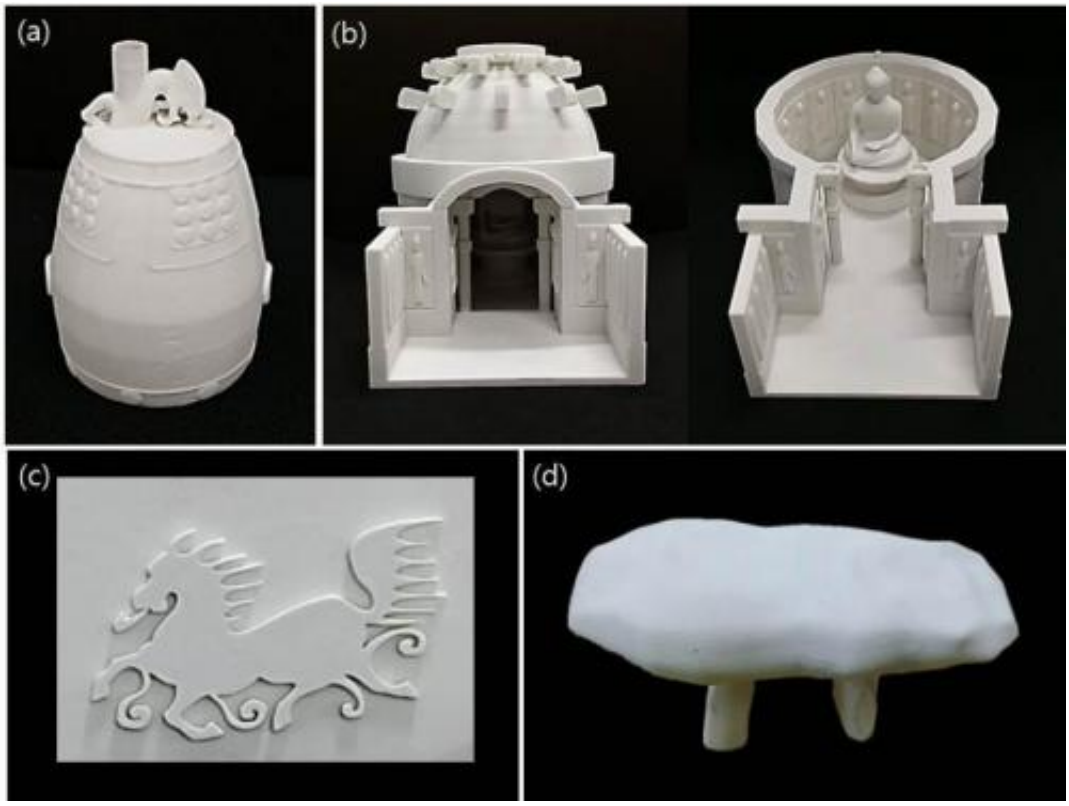
mark of cellulous at the back side of paper; (c~d) on the other hand, after thermal treatment, the backside of braille shows stronger adhesiveness and makes cellulous come off along when the materials are torn off by external force; (e, f) Images to show test results of durability of the existing performation method. Durability test was performed by spinning a metal ball weighting 5N, 12.5m at the speed of 100mm/s on the pattern of materials and comparing the image before and after the experiment. While braille made by performation was easily disrupted (e), braille made from 3D printing and thermal reflow displayed strong durability showing not deformation after the experiment (f). This work has been just accepted for the publication in RSC Advances, 2014.

Presently, materials available for the visually impaired and partially sighted are mostly braille documents or books with a series of raised dots on paper. For basic objects such as apple, tree, etc., raised dots that outline the object was used in picture books. Further, information on subways or public buildings are sometimes difficult to understand not to mention making complex books on contours of maps, earthquake occurrence, and such educational materials in braille was very difficult.

Among all 3D printing technologies, the research team used the layer technique, which stacks each filament layer one at a time based on the data of 3D model. The technology enables the manufacturing of miniature models or prototype of complex 3D objects using computer aided drawing (CAD) at low cost in short time. (Figure 1a) With this method, the shape, size and thickness of the finished product can be controlled by adjusting the number of filament layers.

Objects produced using this technique, will add interest and excitement to the current braille books by putting detailed tables and figures into the context, which in turn will make reading much more interesting for the visually impaired or partially sighted individuals. In addition, changing the colors of filaments bring various colors to 3D models without

difficulties (Figure 1b) and much more complex structures like the contours of a map representing mountainous areas can be produced in colors that are similar to the real thing. Moreover, the time it took to produce educational materials for the visually impaired or partially sighted, which was several month could be cut down to several hours, satisfying the demand from the educational fields of the visually handicapped.



(a) Emile Bell (The Divine Bell of King Seongduk, National Treasure No. 29; (b) Seokguram Grotto (UNESCO World Heritage, National Treasure No. 24); (c) Mud-guard (National Treasure No. 207); (d) Dolmen. These historical relics were printed based on images in the grade 5th social studies textbook. Credit: ©KIST

For tactile objects for the visually impaired or partially sighed, it is important to be harmless to human body and durable, due to the fact that these objects are touched and felt by hands. For this reason, the research team used the thermal reflow processing for surface treatment. If the surface of the produced object is treated with temperatures of 160°C or higher, the solid filament melts to fill the tiniest crevices and gets absorbed into the object creating a surface with better adhesiveness (Figure 2). The surface treated objects are made from plastic hence it is more durable than objects made out of paper not to mention being more resistant to external impact thanks to the treatment (Figure 3). The thermal reflow treatment can also reduce the surface roughness of objects made by 3D printing process, which is created in the production stage.

This newly developed surface treatment technique not only works for paper but also on plastic, metal, ceramics, and other various materials in controlling the adhesiveness between braille and the surface. Also, using 3D printer to produce teaching materials such as a map of the nation or growing process of animals or plants will surly add to the educational development of the visually impaired and partially sighted students in understanding the context and materials much better.

Dr. Kwang-Ryeol Lee Director-General of the Institute for Multidisciplinary Convergence of Matter at KIST said, "The materials have been developed to enhance the quality of life and learning of the visually impaired and partially sighted students but, it is also expected to be used in other educational fields for general students. We will put our utmost efforts in R&D that enables a happier life and better education for the physically challenged students."

Provided by Korea Institute of Science and Technology