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3D Printing of Intricate Soft and Wet Systems

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3D printing is getting quite popular now and this technology will be useful to make new micro devices and systems. Our research group focuses on the application of 3D printing to create new soft and wet systems.

In the past decade, several high-strength gels have been developed. These gels are expected to use as a kind of new engineering materials in the fields of industry and medical as substitutes to polyester fibers, which are materials of artificial blood vessels. We consider if various gel material including such high-strength gels are 3D-printable, many new soft and wet systems will be developed since the most intricate shape gels can be printed regardless of the quite softness and brittleness of gels, as shown in Figure 1.

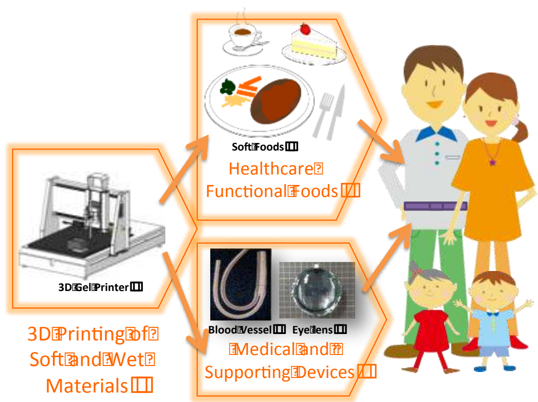

Fig.1: Applications of 3D gel printing.

Recently we have tried to develop an optical 3D gel printer to realize the free-form formation of gel materials[1-3]. We named this apparatus Easy Realizer of Soft and Wet Industrial Materials (SWIM-ER) (shown in Fig.2). The SWIM-ER will be applied to print bespoke artificial organs, including artificial blood vessels, which will be possibly used for both surgery trainings and actual surgery. The SWIM-ER can print one of the world strongest gels, called Double-Network (DN) gels[4,5], by using UV irradiation through an optical fiber.

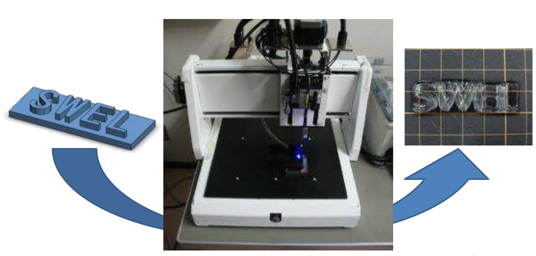

Fig.2: SWIM-ER: 3D gel printer for the fabrication of free-designed high-strength gels from CAD data.

In this paper, we report the two-photon polymerization of gel objects with 3D printing. For this experiment, we use common chemicals we used before[1-3]. A neutral monomer, N,N-dimethylacrylamide (DMAAm) was used as monomer. The DMAAm is convenient to be used due to its high reactivity in gelation and good ductility. The N,N'-methylenbisacrylamide (MBAA) and Eosin Y were used as crosslinker and two-photon initiator, respectively. Triethanolamine (TEA) was used as radical trapper to prevent the deactivation of free radicals. For inducing the two-photon process, femtosecond pulse laser (Spectra Physics MaiTai, 800nm, 700mW, beam diameter 2mm) was used through the 20x objective lens (Olympus MPLN20X). For scanning the stage, Advanced Laser Processing System (ALPS3220) was used[1]. Figure 3 shows the scanning trajectory of two-photon process. The scanning speed was fixed at 0.1mm/sec. The scanning made 40 times to-and-fro motions between both the bridge piers.

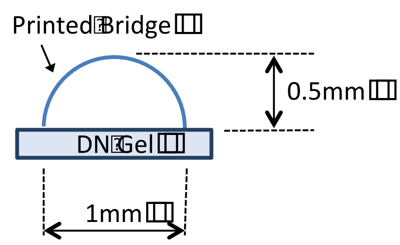

Fig. 3: Design of the gel bridge printed on a gel sheet.

Figure 4 shows the printed gel bridge made by the present experiment. The bridge is so thin and soft that it can stand only in water. It implies that the 3D gel printing can make such a minute and intricate shape, since the 3D printing is unfettered by complexity. This will be a crucial advantage to fabricate complicated living tissues, like as capillary, lymph network and brain.

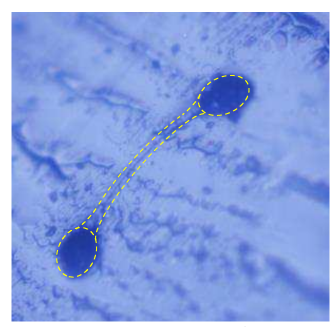

Fig. 4: Optical microscopic photo of the printed gel bridge on the gel sheet. The broken line is a guide to the eye.

References

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