Engineering a Laser Technique to 3D Print Robust Hydrogels for Extracellular Matrices

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For most organ failure patients, organ donations do not exist. But in 5-10 years, patients will be able to grow their own organs by placing stem cells into extracellular matrices (ECMs) taken from donated organ tissue. However, very limited organ donations restrict this technology's accessibility. To create manmade ECMs with no limit to supply, researchers have tried using hydrogels made with different techniques. Yet traditional hydrogels either are not mechanically robust enough for use inside the body, or cannot achieve high-resolution micropores needed to guide complex tissue growth. This research prototyped the first ever laser technique to 3D print robust hydrogels, achieving high-resolution CAD-customizable microfeatures. A commercial laser printer for hard plastics was redesigned to 3D print robust hydrogels. After discovering mechanical erosion of microfeatures from shearing and compression during printing, a series of strategies were manually implemented through hardware reprogramming to effectively eliminate erosion. These approaches led to even higher resolution when applied to a nascent laser technology. To scale up this technique, time-consuming manual erosion prevention needed to be automated. A new mathematical model was built to predict erosion of printed regions. From these predictions, erosion prevention was automated using a new algorithm that adaptively reprograms hardware to minimize predicted erosion below 0.3% per layer. This scalable technique pioneers unprecedented control over robust hydrogel microfeatures, making it more possible to create manmade ECMs from hydrogels for both organ failure and osteoarthritis patients. Industries from soft robotics to vaccine delivery could also create robust hydrogel structures using this technique.

Awards Won:

Second Award of $2,000