Publications with LPKF equipment

Selection of internationally published scientific articles using LPKF equipment

October 2021

Laser & Electronics

TOC: page, system, application

LPKF ProtoLaser U4

Material used:

DuPont AP7164R

Application area:

Bio-medical sensor

Published:

05/2020

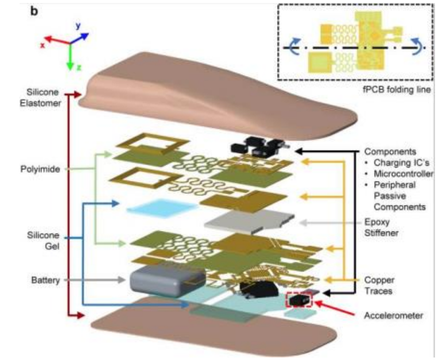
LPKF Laser & Electronics

Mechanoacoustic sensing of physiological processes and body motions via a soft wireless device placed at the suprasternal notch

Skin-mounted soft electronics incorporating high-bandwidth triaxial accelerometers can provide broad classes of physiologically relevant information, such as mechanoacoustic signatures of underlying body processes (such as those captured by a stethoscope) and precision kinematics of core body motions. Here, we describe a wireless device designed to be conformally placed on the suprasternal notch for the continuous measurement of mechanoacoustic signals, from subtle vibrations of the skin at accelerations of ~10^{-3} m·s^{-2} to large motions of the entire body at ~10 m·s^{-2}, and at frequencies up to ~800 Hz. Because the measurements are a complex superposition of signals ...

Fabrication began with patterning a sheet of fPCB (12 µm thick top and bottom Cu layer, 25 µm thick middle PI layer, AP7164R, DuPont) into the necessary shapes using a ultraviolet (UV) laser cutter (LPKF U4). A CO_2 laser cutter (VLS3.50) defined pieces of Flame Retardant 4 (FR-4) board (0.381 mm, McMaster Carr 1331T37) into geometries matched to half of the sizes of the two electronic islands (Fig. 1b). Folding the island regions of the fPCB around the FR-4 and bonding them in place using an adhesive (Loctite Tak Pak 444) yielded a dual-sided structure. Solder paste (Chip Quik TS391LT) joined the various electronic and sensor components onto the fPCB by reflow using a heat gun.

bio-medical devices, health monitoring, flexible electronics,



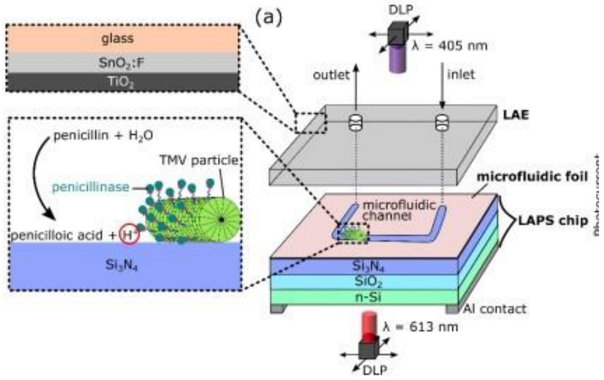
Simpson Querry Institute, Northwestern University, Chicago, IL, USA

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7035153/

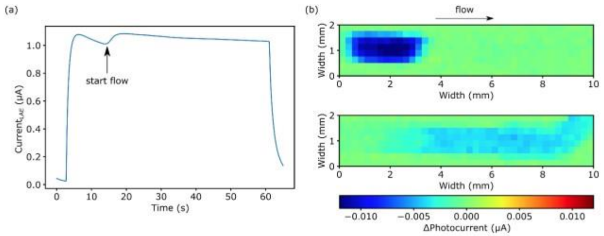
Light-Addressable Actuator-Sensor Platform for Monitoring and Manipulation of pH Gradients in Microfluidics: A Case Study with the Enzyme Penicillinase

light-addressable potentiometric sensor; light-addressable electrode; actuator-sensor system; enzyme kinetics; microfluidics

The feasibility of light-addressed detection and manipulation of pH gradients inside an electrochemical microfluidic cell was studied. Local pH changes, induced by a light-addressable electrode (LAE), were detected using a light-addressable potentiometric sensor (LAPS) with different measurement modes representing an actuator-sensor system. Biosensor functionality was examined depending on locally induced pH gradients with the help of the model enzyme penicillinase, which had been immobilized in the microfluidic channel. The surface morphology of the LAE and enzyme-functionalized LAPS was studied by scanning electron microscopy. Furthermore, the penicillin …



To prepare the LAPS/microfluidic foil/LAE sandwich structure (schematically depicted in [Figure 1](#)a, a ~86 µm thick double-sided adhesive microfluidic tape (3M^{TM}, St. Paul, MN, USA) was patterned by laser cutting using a ProtoLaser U3 (LPKF Laser and Electronics AG, Garbsen, Germany). A 20 × 20 mm^2 rectangle with a 1.0 mm wide channel was cut out of the tape. The LAE was cleaned in an ultrasonic bath with acetone, 2-isopropanol, ethanol and deionized water and finally dried with nitrogen. Afterwards, the laser-cut microfluidic foil was stuck onto the TiO_2 surface of the LAE, positioning the drilled holes of the LAE at the inlet and outlet of the microfluidic channel. In the final step, the TMV- and penicillinase-functionalized LAPS chip was placed below the LAE-microfluidic…



Institute of Nano- and Biotechnologies, Aachen University of Applied Sciences, 52428 Jülich, Germany

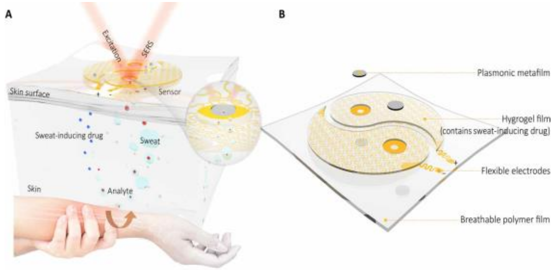
https://www.mdpi.com/2079-6374/11/6/171/htm

LPKF ProtoLaser U4

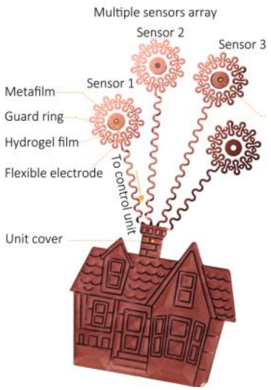
Wearable plasmonic-metasurface sensor for noninvasive and universal molecular fingerprint detection on biointerfaces

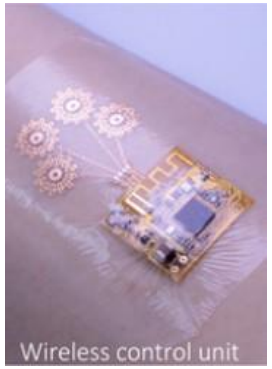
Wearable bio-sensor, flexible electronics, medical research

Wearable sensing technology is an essential link to future personalized medicine. However, to obtain a complete picture of human health, it is necessary but challenging to track multiple analytes inside the body simultaneously. Here, we present a wearable plasmonic-electronic sensor with “universal” molecular recognition ability. Flexible plasmonic metasurface with surface-enhanced Raman scattering (SERS)–activity is introduced as the fundamental sensing component in a wearable sensor since we solved the technical challenge of maintaining the plasmonic activities of their brittle nanostructures under various deformations. Together with a flexible electronic sweat extraction …



Fabrication of the integrated wearable sensor began by fixing a Cu film (thickness, 6 µm) onto a silica wafer with a 10-µm cured PDMS layer as a temporary adhesive layer. The Cu film was then patterned by a laser direct writing technique (LPKF ProtoLaser U4, LPKF Laser & Electronics AG, Germany), which defined the spiral fractal electrodes. A water-soluble tape (3M, USA) enabled the retrieval of the spiral electrodes from the handle substrate and the subsequent transfer to a thin, breathable polymer adhesive tape (3M Tegaderm). Then, a 100-µm hydrogel film containing 10% acetylcholine chloride with the desired shape was transferred onto the electrode. Afterwards, a through-hole was cut in the hydrogel to expose the guard ring on centers of the yin-yang electrodes, where an NC superlattice film can be mounted.





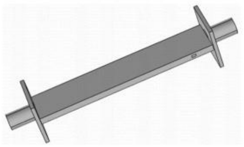
College of Biosystems Engineering and Food Science, Zhejiang University, Hangzhou 310058, China.

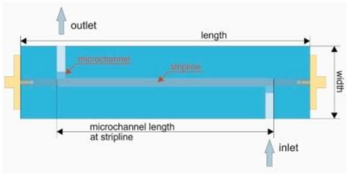
https://advances.sciencemag.org/content/7/4/eabe4553

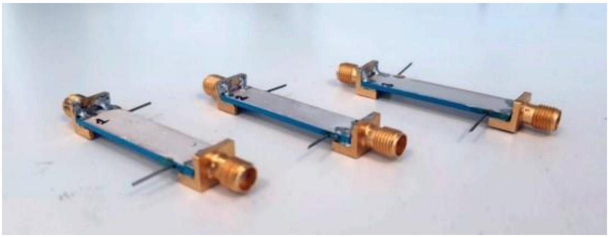
LPKF ProtoLaser U

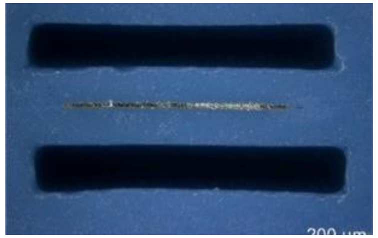
A Stripline-Based Integrated Microfluidic-Microwave Module

Microwave, microfluidics, stripline









The paper presents the preliminary results on the development of an integrated stripline-based microwave-microfluidic module. The measurements were performed in a frequency range from 300 MHz up to 12 GHz, with the microchannel filled with three different test fluids—deionized water, the ethanol-water solution and pure ethanol. Due to the higher-than-expected losses in transmittance, the selected module was examined with use of the cross-sections taken along its length. The possible causes were highlighted and described. Likewise, the proposed areas of further investigations have been clearly described.

Device Fabrication

The stripline was deposited on the fourth layer using a screen printing method with the ESL903A silver conductive paste (sheet resistance ≤ 2 mΩ/□) with use of the Aurel VS 1520A screen printer (Aurel S.p. A, Modilgiana, Italy). The microchannels were fabricated using the LPKF ProtoLaser U laser system (λ = 355 nm, LPKF Laser&Electronics, Garbsen, Germany). Thereafter, all layers were stacked together and laminated in the isostatic press with reduced pressure (compared to the 20 MPa recommended by the manufacturer), for 10 min at a temperature of 70 °C.

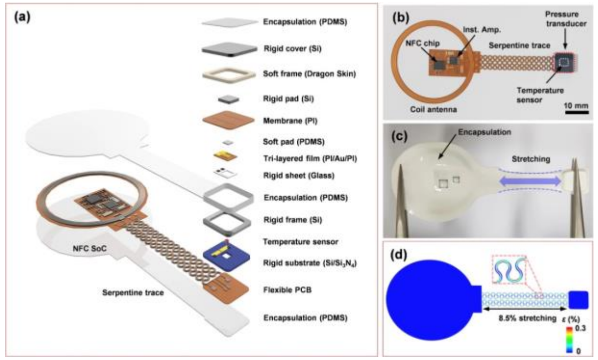
Department of Microsystems, Faculty of Microsystem Electronics and Photonics, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland

https://www.mdpi.com/1996-1073/14/9/2439/htm

Battery-free, wireless soft sensors for continuous multi-site measurements of pressure and temperature from patients at risk for pressure injuries

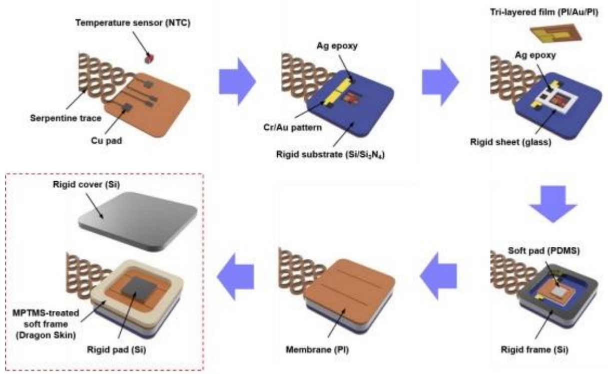
bio-medical devices, health monitoring, wireless electronics, flexible electronics,

Capabilities for continuous monitoring of pressures and temperatures at critical skin interfaces can help to guide care strategies that minimize the potential for pressure injuries in hospitalized patients or in individuals confined to the bed. This paper introduces a soft, skin-mountable class of sensor system for this purpose. The design includes a pressure-responsive element based on membrane deflection and a battery-free, wireless mode of operation capable of multi-site measurements at strategic locations across the body. Such devices yield continuous, simultaneous readings of pressure and temperature in a sequential readout scheme from a pair of primary antennas mounted under …



Fabrication of the battery-free, wireless electronic system

Fabrication began with patterning a flexible PCB substrate (Pyralux AP8535R, DuPont) to define electrical connections, vias, and the device outline with a direct UV (355-nm) laser ablation system (ProtoLaser U4, LPKF), followed by ultrasonic cleaning successively in oxide remover (Flux, Worthington Inc) for 2 min, deionized (DI) water for 2 min, and isopropyl alcohol (IPA, MG Chemicals) for 2 min to remove oxidation and organic residue. Electronic components included an NFC SoC (RF430FRL152H, Texas Instruments), an instrumentation amplifier (INA333, Texas Instruments), resistors, and capacitors, each placed using reflow soldering with low-temperature, solder paste…



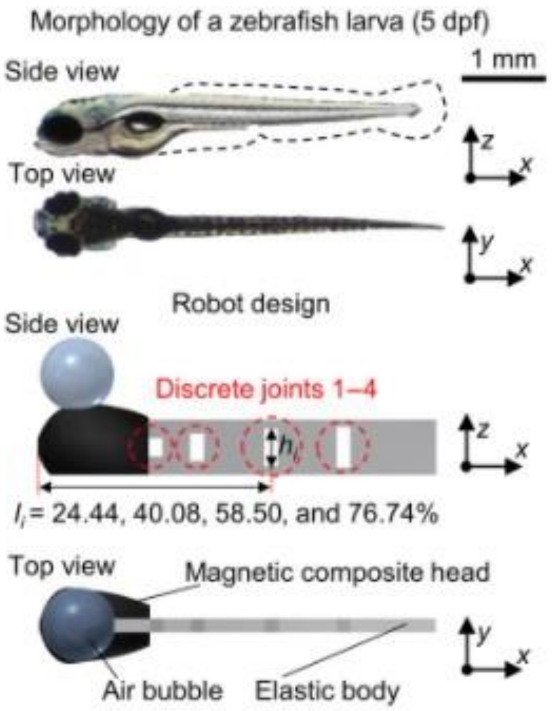
Center for Bio-Integrated Electronics, Northwestern University, Evanston, IL, USA

https://www.nature.com/articles/s41467-021-25324-w

Effect of body stiffness distribution on larval fish–like efficient undulatory swimming

Medical robots, robotic swimmers, energy-efficient propulsion

Energy-efficient propulsion is a critical design target for robotic swimmers. Although previous studies have pointed out the importance of nonuniform body bending stiffness distribution (k) in improving the undulatory swimming efficiency of adult fish–like robots in the inertial flow regime, whether such an elastic mechanism is beneficial in the intermediate flow regime remains elusive. Hence, we develop a class of untethered soft milliswimmers consisting of a magnetic composite head and a passive elastic body with different k. These robots realize larval zebrafish–like undulatory swimming at the same scale. Investigations reveal that uniform k and high swimming frequency …



The elastic body is made of soft silicone rubber (Ecoflex 00-30, Smooth-On Inc.). A small amount of pigment (Silc Pig, Smooth-On Inc.) is mixed into the silicon rubber (mass ratio of 0.1:1) to assist laser cutting in the later procedures. The mixture is cast onto a flat poly(methyl methacrylate) (PMMA) plate coated with a thin layer of parylene C (6 µm thick), which is used to ease the release of the cured rubber. After curing for 1 hour on the hot plate at 60°C, a thin film with a thickness of around 170 µm is formed. The ultraviolet (UV) laser (ProtoLaser U3, LPKF Laser & Electronics AG) is used to cut the desired body designs out of the film. All bodies are with the overall dimension of 3.5 mm by 0.6 mm by 0.17 mm (length by width by height).

Physical Intelligence Department, Max Planck Institute for Intelligent Systems, 70569 Stuttgart, Germany.

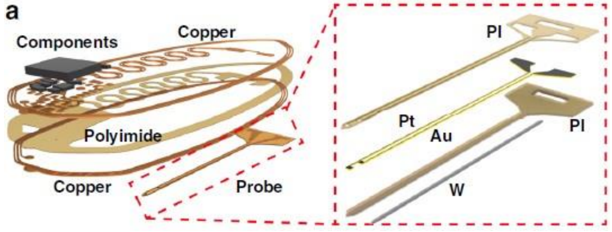
https://advances.sciencemag.org/content/7/19/eabf7364

LPKF ProtoLaser U4

Wireless, battery-free, and fully implantable electrical neurostimulation in freely moving rodents

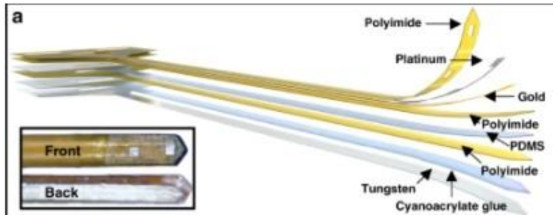
Biomedical engineering, health care, microfluidics

Implantable deep brain stimulation (DBS) systems are utilized for clinical treatment of diseases such as Parkinson’s disease and chronic pain. However, long-term efficacy of DBS is limited, and chronic neuroplastic changes and associated therapeutic mechanisms are not well understood. Fundamental and mechanistic investigation, typically accomplished in small animal models, is difficult because of the need for chronic stimulators that currently require either frequent handling of test subjects to charge battery-powered systems or specialized setups to manage tethers that restrict experimental paradigms and compromise insight. To overcome these challenges, we demonstrate a fully …



Flexible circuit fabrication

Copper traces were defined on Pyralux (AP8535R; constituent layers: 17.5-µm copper, 75-µm polyimide, and 17.5-µm copper) using a UV (355-nm) laser ablation system (LPKF; Protolaser U4). The flexible circuits were cleaned in stainless steel flux (Superior Flux and Manufacturing Company; Superior #71) for 2 minin an ultrasonic cleaner (Vevor; Commercial Ultrasonic Cleaner 2 L) and rinsed with deionized (DI) water. Via connections were established manually with copper wire (25 µm) and low-temperature solder (Chip Quik; TS391LT). Combinations of 0201 capacitors (108 pF) were used to tune the power harvesting antenna. A half-bridge rectifier was built with …



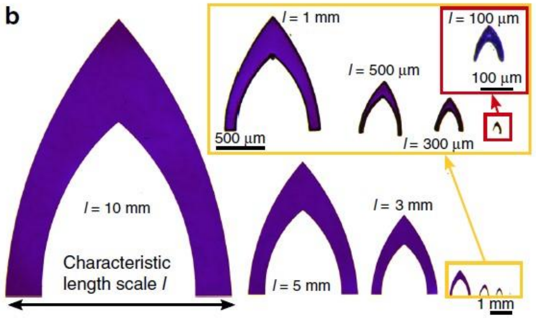
Department of Biomedical Engineering, University of Arizona, Tucson, AZ, 85721, USA

https://www.nature.com/articles/s41378-021-00294-7

Multifunctional and biodegradable self-propelled protein motors

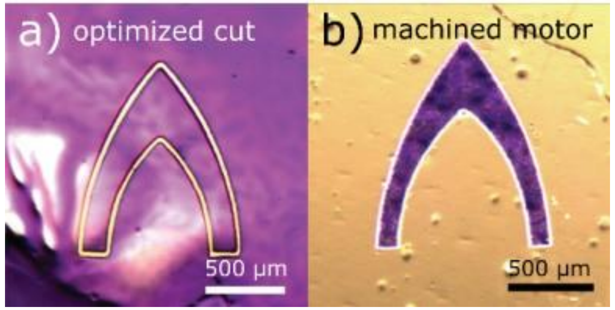
Locomotion, micro-mili robots, cargo transfer, bio-materials

A diversity of self-propelled chemical motors, based on Marangoni propulsive forces, has been developed in recent years. However, most motors are non-functional due to poor performance, a lack of control, and the use of toxic materials. To overcome these limitations, we have developed multifunctional and biodegradable self-propelled motors from squid-derived proteins and an anesthetic metabolite. The protein motors surpass previous reports in performance output and efficiency by several orders of magnitude, and they offer control of their propulsion modes, speed, mobility lifetime, and directionality by regulating the protein nanostructure via local and external stimuli, resulting in programmable and complex locomotion.



Motor fabrication

SRT were extracted from the tentacles of L. vulgaris squid from Tarragona (Spain)35. SRT protein was dissolved in HFIP to a concentration of 50 mg mL−1, and 1% crystal violet dye was added. 100 µL of solution were cast on polydimethylsiloxane substrates and left to evaporate for at least 3 h, yielding 20 µm protein films. The films were cut in a LPKF ProtoLaser U3 laser cutter (0.189 W, 50 kHz) to the desired motor design (characteristic lengths from 100 µm to 10 mm, Supplementary Fig. 3). Laser micromachining details are described in Supplementary Fig. 2. After machining, an array of motors were mechanically peeled off from the substrate (tweezers and needle tip) and transferred for characterization and analysis.



Physical Intelligence Department, Max Planck Institute for Intelligent Systems, 70569, Stuttgart, Germany

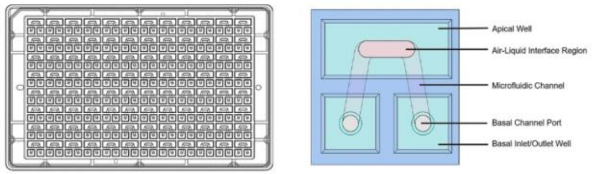
https://www.nature.com/articles/s41467-019-11141-9

LPKF ProtoLaser U4

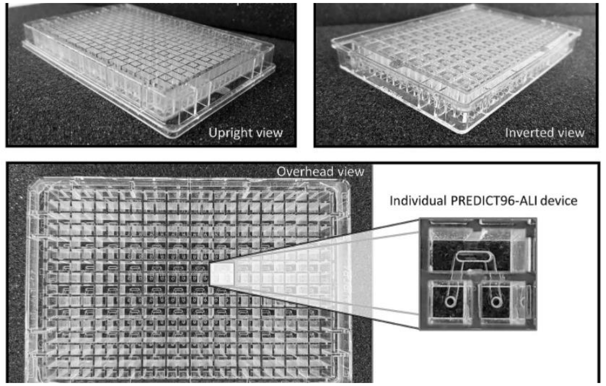
High-throughput human primary cell-based airway model for evaluating influenza, coronavirus, or other respiratory viruses in vitro

microfluidics, organ-on-chip, viral infection, SARS-CoV-2

Influenza and other respiratory viruses present a significant threat to public health, national security, and the world economy, and can lead to the emergence of global pandemics such as from COVID-19. A barrier to the development of effective therapeutics is the absence of a robust and predictive preclinical model, with most studies relying on a combination of in vitro screening with immortalized cell lines and low-throughput animal models. Here, we integrate human primary airway epithelial cells into a custom-engineered 96-device platform (PREDICT96-ALI) in which tissues are cultured in an array of microchannel-based culture chambers at an air–liquid interface, in a configuration …



To fabricate the PREDICT96-ALI culture plate, a UV laser system (Protolaser U4: LPKF Laser and Electronics, Garbsen, Germany) was used to laser-cut thin films of cyclic olefin polymer (COP) (ZF14-188: Zeon Corp., Tokyo, Japan) and cyclic olefin copolymer (8007 COC: Tekni-plex, Wayne, PA, USA). The COP layers were adhered together using low-glass transition temperature COC in a heated hydraulic press (Carver Inc., Wabash, IN, USA), and were separated with a 24 µm-thick track-etched polycarbonate membrane with pore diameter of 0.4 or 1 µm (It4ip S.A., Louvain-la-Neuve, Belgium) patterned with an array of holes to provide fluidic access ports to the bottom channel. The microfluidic stack is attached to a modified 384-well COP plate (Aurora Microplates, Whitefish, …



Bioengineering Division, Draper, Cambridge, MA, 02139, USA

https://www.nature.com/articles/s41598-021-94095-7

LPKF ProtoLaser U4

Material used:
COC, Kapton, Ultem, Viton

Application area:
Biotechnology

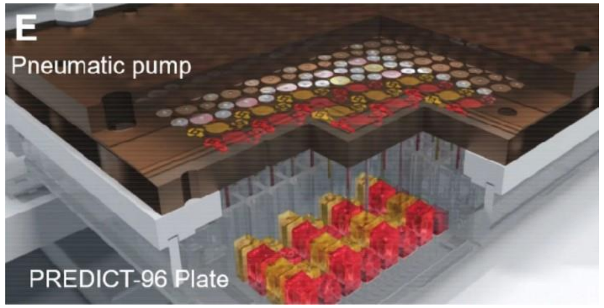
Published:
09/2020

LPKF Laser & Electronics

A high-throughput microfluidic bilayer co-culture platform to study endothelial-pericyte interactions

Organ-on-chip, microfluidic, qPCR

Microphysiological organ-on-chip models offer the potential to improve the prediction of drug safety and efficacy through recapitulation of human physiological responses. The importance of including multiple cell types within tissue models has been well documented. However, the study of cell interactions in vitro can be limited by complexity of the tissue model and throughput of current culture systems. Here, we describe the development of a co-culture microvascular model and relevant assays in a high-throughput thermoplastic organ-on-chip platform, PREDICT96. The system consists of 96 arrayed bilayer microfluidic devices containing retinal microvascular endothelial …



The pumps were fabricated using methods previously described44. In brief, the films comprising the fluidic and pneumatic layers (Kapton polyimide, Ultem polyetherimide, and Viton) were prepared by annealing and tacking an adhesive film (RFlex 1000 with a thickness of 12.5 µm) when necessary and through-cut using a UV laser system (LPKF). The layers were subsequently assembled and laminated at 175 °C in a heated press. To calibrate the pumps, a fluorescent solution of 6 µM fluorescein (Millipore Sigma, Burlington, MA) in PBS was pumped through the device in a 384 well-plate (Aurora Microplates) for a set number of cycles. The output was measured using a plate reader (SpectraMax) to determine the stroke volume of each of the 192 pumps. The average stroke volume and ….

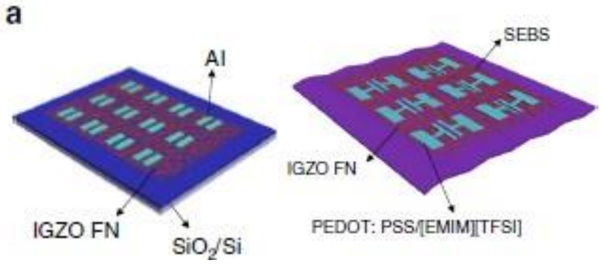
The Charles Stark Draper Laboratory Inc., 555 Technology Square, Cambridge, MA, 02139, USA

https://www.nature.com/articles/s41598-021-90833-z

LPKF ProtoLaser R

Flexible and stretchable metal oxide nanofiber networks for multimodal and monolithically integrated wearable electronics

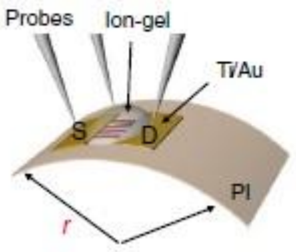
Wearable electronics, stretchable resistors, e-skin devices

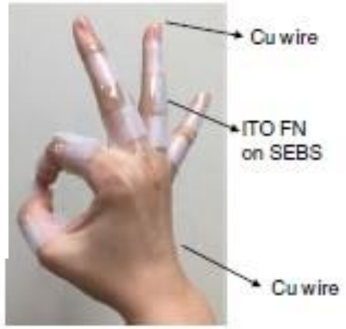


Fiber-based electronics enabling lightweight and mechanically flexible/stretchable functions are desirable for numerous e-textile/e-skin optoelectronic applications. These wearable devices require low-cost manufacturing, high reliability, multifunctionality and long-term stability. Here, we report the preparation of representative classes of 3D-inorganic nanofiber network (FN) films by a blow-spinning technique, including semiconducting indium-gallium-zinc oxide (IGZO) and copper oxide, as well as conducting indium-tin oxide and copper metal. Specifically, thin-film transistors based on IGZO FN exhibit negligible performance degradation after one thousand bending cycles and …

Fabrication of stretchable resistors

SEBS substrates (~1-mm thick) were fabricated by drop-casting an ~1.5 mL SEBS toluene solution (200 mg mL−1) on a glass slide (2.5 × 7.5 cm2) and drying at RT overnight. A 25-µm-thick PI film was partially cut to define electrode patterns using a laser cutter (LPKF ProtoLaser R)54. The gap between two neighbor rectangular patterns was 1000 µm in width and 100 µm in length. Then the resulting patterned PI film was placed on a SEBS substrate, followed by spin-coating a PEDOT:PSS+[EMIM][TFSI] solution (obtained by dissolving 20 mg of [EMIM][TFSI] in 2 mL of PEDOT:PSS) at 1500 rpm for 1 min as stretchable electrodes.





Department of Chemistry and the Materials Research Center, Northwestern University, Evanston, IL 60208, USA.

https://www.nature.com/articles/s41467-020-16268-8

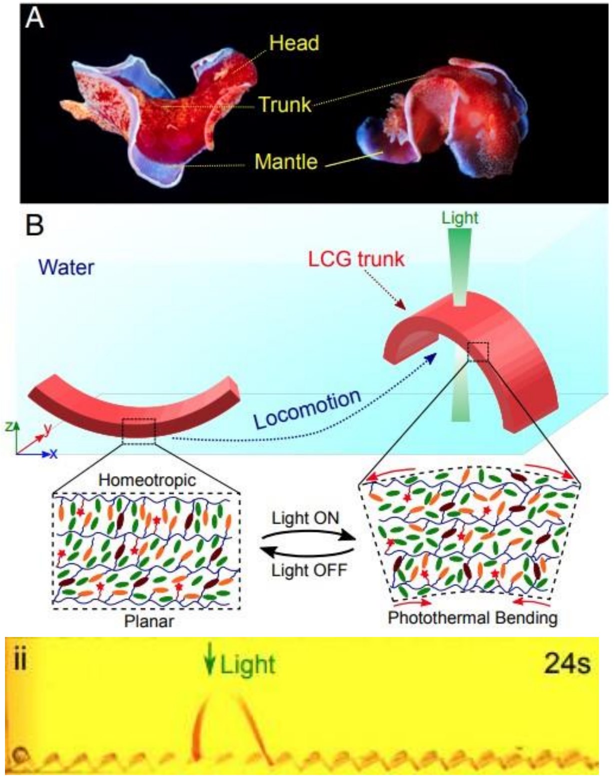
LPKF ProtoLaser R

Bioinspired underwater locomotion of light-driven liquid crystal gels

Liquid Cristal Gel, soft materials, soft robots, underwater locomotion, biomimetics

Soft-bodied aquatic invertebrates, such as sea slugs and snails, are capable of diverse locomotion modes under water. Recapitulation of such multimodal aquatic locomotion in small-scale soft robots is challenging, due to difficulties in precise spatiotemporal control of deformations and inefficient underwater actuation of existing stimuli-responsive materials. Solving this challenge and devising efficient untethered manipulation of soft stimuli-responsive materials in the aquatic environment would significantly broaden their application potential in biomedical devices. We mimic locomotion modes common to sea invertebrates using monolithic liquid crystal gels (LCGs) with inherent light …

All mixtures were melted to their isotropic phase at 100 °C, stirred for 1 h, and then injected into cells of different alignment configurations. The filled cells were cooled down to 25 °C (~1 $°C \cdot min^{-1}$) and were exposed to 365-nm ultraviolet (UV) light (Herolab) with an intensity of ~5 $mW \cdot cm^{-2}$ for 30 min for cross-linking. Afterward, LCN and LCG samples were cut to desired shapes and sizes using a laser cutter (ProtoLaser R cutter; LPKF Laser and Electronics) and harvested by immersion in water. All samples were conditioned in water for several days prior to any experiments. Note that our method in the synthesis of LCGs slightly differs from some techniques reported in previous studies where a prepolymerized LCN becomes swollen with a low-molecular-weight nematogen. …



Physical Intelligence Department, Max Planck Institute for Intelligent Systems, 70569, Stuttgart, Germany

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