Publications with LPKF equipment

Selection of internationally published scientific articles using LPKF equipment

May 2024

LPKF
Laser & Electronics

TOC: page, system, application

LPKF ProtoLaser R4

Material used: **iridium oxide**

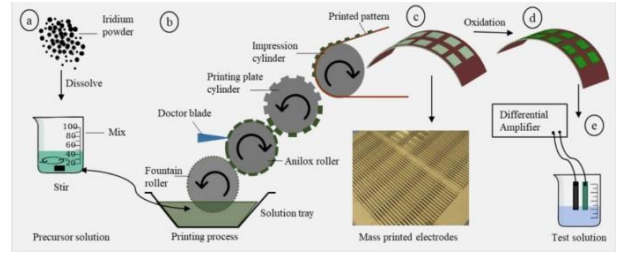
Application area: **Sensors**

Published: **04/2023**

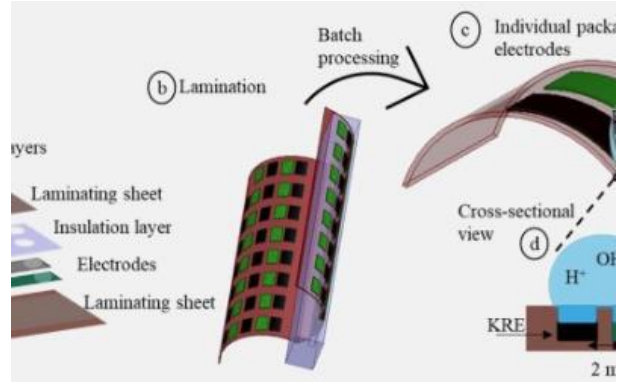
Printable and Flexible Iridium Oxide-Based pH Sensor by a Roll-to-Roll Process

Flexible, pH sensor, iridium oxide, sustainable

A flexible pH sensor based on using iridium oxide (IrOx) as the sensing film was developed by the roll-to-roll (R2R) process. The inert and biocompatible properties of IrOx make it a desired metal oxide for pH-sensing applications. The flexible substrates being continuously processed by the R2R technique provides the advantages of scalability, reconfigurability, resiliency, on-demand manufacturing, and high throughput, without the need for vacuum systems. Potential sweeps by cyclic voltammetry across the IrOx film against commercial and planar Ag/AgCl electrodes validated the reversible electrochemical mechanisms.



The reference electrodes (KREs) were prepared by an automated stencil method on the same polyimide film with Au and Cu deposited. A stainless steel doctor blade with a moving speed adjusted to 1 inch/s at a 45° angle was used across the stencil. Commercial Ag/AgCl paste (ASLCo., Tokyo, Japan) was stencil-printed on a 6” × 6” flexible polyimide sheet. The samples were then heated to 120 °C for 10 min to dry. The measured thickness of the film was 13 µm. The KWE and KRE electrodes were individualized from the mass-printed batch by a singulation process. A laser-cutting machine ProtoLaser (LPKF R4, Naklo, Germany), adjusted to a speed of 500 mm/s and a channel width of 200 µm, produced electrode sizes of 2 mm × 15 mm.



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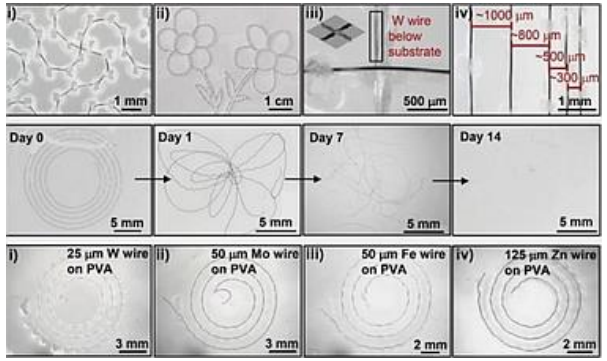
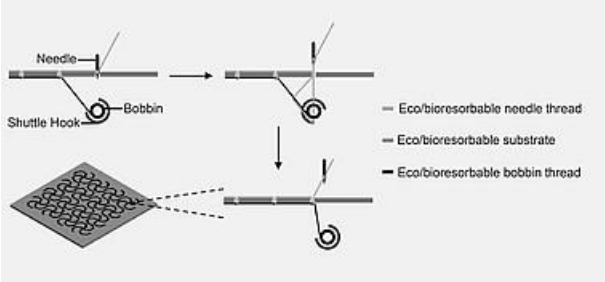
https://www.mdpi.com/2227-9040/11/5/267

A Sewing Approach to the Fabrication of Eco/bioresorbable Electronics

eco/bioresorbable stretchable interconnects, RFID tags, temporary cardiac pacemakers, wireless light emitters



Eco/bioresorbable electronics represent an emerging class of technology defined by an ability to dissolve or otherwise harmlessly disappear in environmental or biological surroundings after a period of stable operation. The resulting devices provide unique capabilities as temporary biomedical implants, environmental sensors, and related systems. Recent publications report schemes to overcome challenges in fabrication that follow from the low thermostability and/or high chemical reactivity of the eco/bioresorbable constituent materials. Here, this work reports the use of high-speed sewing machines, as the basis for a high-throughput manufacturing technique that …



Fabrication and Characterization of Stretchable Serpentine Interconnects

A serpentine pattern of W wires (diameter: 50 µm) was embroidered onto a PVA substrate. A laser cutter (LPKF ProtoLaser R) was used to remove PVA material from regions away from the wires, to form a corresponding serpentine ribbon of PVA with a width of 1 mm. Encapsulating the embroidered serpentine W wire between two layers of PU completed the fabrication of the stretchable serpentine interconnect. Methods for preparing PU films appear elsewhere. Each interconnect sample was clamped at its two ends and stretched, while connected to a multimeter to record the resistance at different strains. For evaluation of the reliability, the structures were …

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https://onlinelibrary.wiley.com/doi/10.1002/smll.202305017

LPKF ProtoLaser U4

Material used:

Flex N/A

Application area:

Bioresorbable electronic

Published:

4/2024

Ultrathin, Transferred Layers of Silicon Oxynitrides as Tunable Biofluid Barriers for Bioresorbable Electronic Systems

biofluid barriers; bioresorbable electronics; electronics packaging; silicon oxynitrides; transient electronic

Bio/ecoresorbable electronic systems create unique opportunities in implantable medical devices that serve a need over a finite time period and then disappear naturally to eliminate the need for extraction surgeries. A critical challenge in the development of this type of technology is in materials that can serve as thin, stable barriers to surrounding ground water or biofluids, yet ultimately dissolve completely to benign end products. This paper describes a class of inorganic material (silicon oxynitride, SiON) that can be formed in thin films by plasma-enhanced chemical vapor deposition for this purpose. In vitro studies suggest that SiON and its dissolution products are …

Fabrication of Bioresorbable Devices Encapsulated by Trilayer Materials: The bioresorbable device here consisted of an RF energy harvester, which included two Mo coils (thickness: ≈50 µm) stacked on top of one another and spaced with an ≈10 µm thick PLGA dielectric layer. The energy harvester provided wireless power to a commercial LED. A UV laser cutter (LPKF, ProtoLaser U4) defined the coil structure by selectively removing Mo. Conductive wax electrically connected all components of the device. Two pieces of trilayer materials bonded above and below the device by heating to 70 °C for 15 min sealed the system. To minimize leakage issues at the edges during the PBS soaking test, biodegradable polyanhydrides were utilized to cover the entire wireless device.

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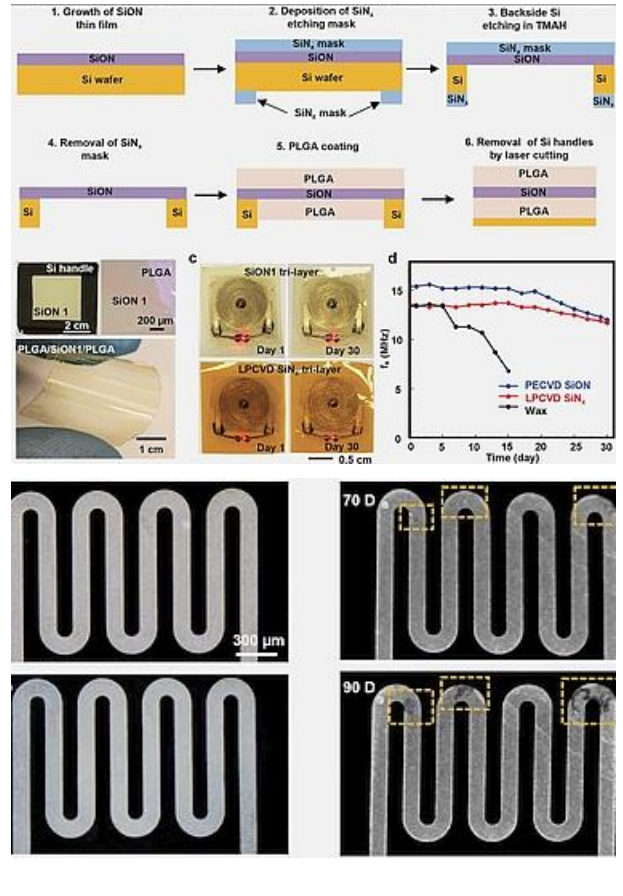
https://onlinelibrary.wiley.com/doi/10.1002/adma.202307782



LPKF ProtoLaser U4

Material used: **Zn foils, PDMS**

Application area: **Implantable medical sensors**

Published: **4/2024**

Bioresorbable, wireless, passive sensors for continuous pH measurements and early detection of gastric leakage

Continuous monitoring of biomarkers at locations adjacent to targeted internal organs can provide actionable information about postoperative status beyond conventional diagnostic methods. As an example, changes in pH in the intra-abdominal space after gastric surgeries can serve as direct indicators of potentially life-threatening leakage events, in contrast to symptomatic reactions that may delay treatment. Here, we report a bioresorbable, wireless, passive sensor that addresses this clinical need, designed to locally monitor pH for early detection of gastric leakage. A pH-responsive hydrogel serves as a transducer that couples to a mechanically optimized inductor-capacitor circuit…

Fabrication of the pH sensor: Laser cutting (U4, LPKF Laser & Electronics) foils of Zn (Goodfellow) with thickness of 100 µm yielded the inductor with serpentine-shaped spiral coils. Resting the Zn inductor in a polydimethylsiloxane (PDMS) mold (Sylgard 184, Dow; prepared separately via 3D printing and replica molding) and infusing molten bioresorbable wax (a mixture of beeswax and candelilla wax in a weight ratio of 2:1; Sigma-Aldrich) into the channels created a uniform, electrically insulating coating (average thickness about 50 to 100 µm). Demolding the wax-coated Zn coil followed by casting the pH-responsive hydrogel prepolymer between a pair of microscope slides (75 × 50 × 1 mm with a 12-mm-diameter hole drilled in the center) with a 400-µm spacer defined …

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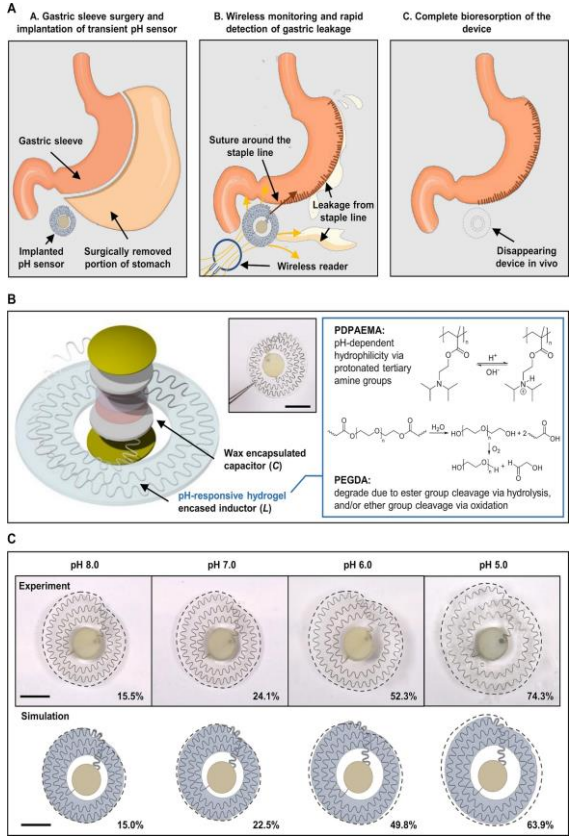
https://www.science.org/doi/10.1126/sciadv.adj0268

bioresorbable, wireless, passive pH-sensor, implanted senzor



LPKF ProtoLaser U4

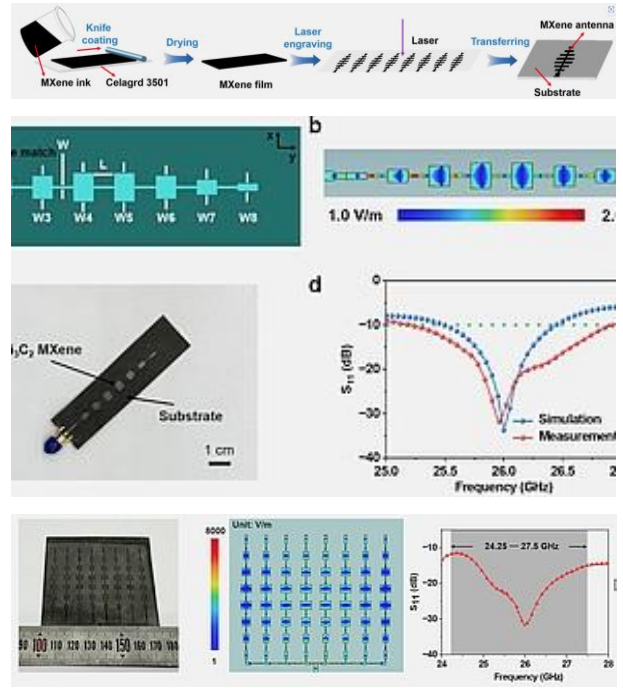
Material used:
Ti3C2 Mxene, Rogers 5880

Application area:
5G Antenna

Published:
7/2023

High-Conductivity MXene Film-Based Millimeter Wave Antenna for 5G Applications

MXene antenna; millimeter wave; 5G; wideband; low sidelobe



Millimeter wave antennas have the advantage of high directivity, miniaturization, high resolution and data transfer speed, wide bandwidth, and lower latency. In this work, a millimeter wave planar array antenna (PAA) with the characteristics of wideband and low sidelobes, which consists of eight identical linear array antenna (LAA) based on Ti3C2 MXene, is designed and fabricated. It is the first time that MXene antennas are proposed for a 5G millimeter wave antenna application. MXene PAA has a high realized gain of 22.22 dBi and a −10 dB impedance bandwidth of measurement covering the range from 24 GHz to 28 GHz, including the 5G FR2—n258 frequency band. With Chebyshev current distribution, the MXene PAA has a half-power beam width of 10.2° and 10.8° in the …

Antenna fabrication: To satisfy the requirements of the design, antenna parameters are optimized. MXene antennas are fabricated by laser engraving method [29]. A commercial and high-precision laser engraver LPKF ProtoLaser U4 with an accuracy of 20 µm is chosen. Export the model of MXene array antenna obtained from the optimization to a DXF file. LPKF CircuitPro PL 2.0 was used to calculate the laser carving path of the designed array antenna. Then, LPKF Laser & Electronics ProtoLaser S directly fabricated the LAA and PAA with high resolution according to the laser carving path calculated by the calculation software. Therefore, the MXene antenna can be fabricated rapidly, efficiently and cost-effectively. Figure 1a shows the preparation process diagram of the MXene

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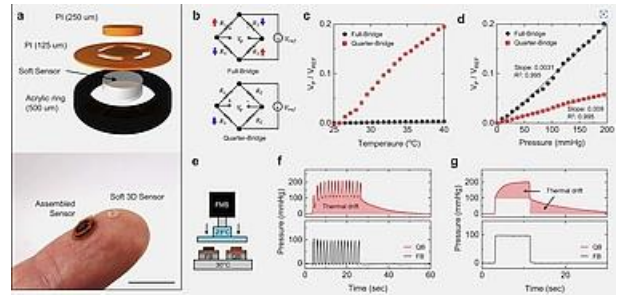
https://www.mdpi.com/2073-4352/13/7/1136

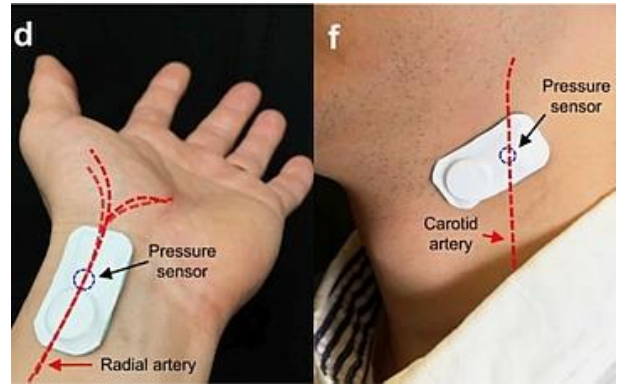
Soft, full Wheatstone bridge 3D pressure sensors for cardiovascular monitoring

Wheatstone full-bridge, 3D blood pressure sensor,

Variations in parameters associated with the ambient environment can introduce noise in soft, body-worn sensors. For example, many piezoresistive pressure sensors exhibit a high degree of sensitivity to fluctuations in temperature, thereby requiring active compensation strategies. The research presented here addresses this challenge with a multilayered 3D microsystem design that integrates four piezoresistive sensors in a full-Wheatstone bridge configuration. An optimized layout of the sensors relative to the neutral mechanical plane leads to both an insensitivity to temperature and an increased sensitivity to pressure, relative to previously reported devices that rely on similar …



Fabrication of the electronics: The FPCB design layouts were created using EAGLE CAD version 9 (Autodesk). To fabricate the FPCB, a sheet of FPCB with a thickness of 12 μm for the top and bottom copper layers and 25 μm for the middle PI layer (AP7164R, DuPont) was patterned into the required shapes using an ultraviolet laser cutter (LPKF U4). The 3D pressure sensor, along with various surface-mount components including the BLE SoC (nRF52832, Nordic Semiconductor), BLE antenna (2450AT18A100, Johanson Technology Inc.), AMP (INA333, Texas Instruments), reference resistors (RMCF0201FT, Stackpole Electronics Inc.), and temperature sensor components (NTC; NCP03XH, Murata), were joined to the FPCB using solder paste (Chip Quik TS391LT) and reflowed using a …



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https://www.science.org/doi/10.1126/sciadv.ade2450

LPKF ProtoLaser U4

Material used:
Au on PI, Dupont Pyralux AP8535R

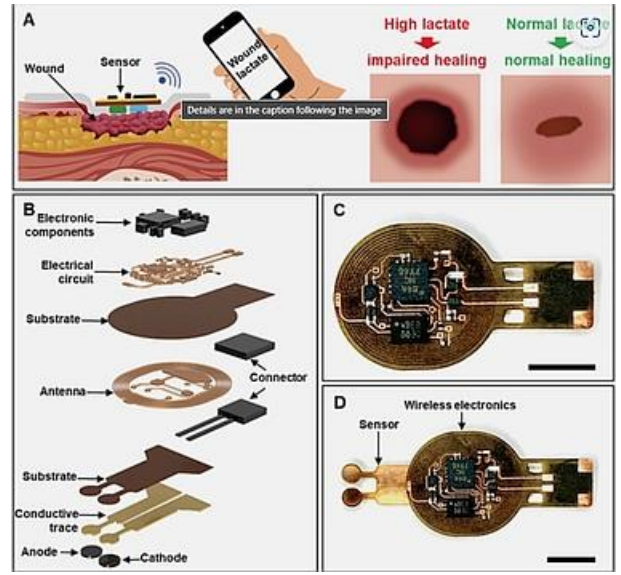
Application area:
Medical sensors

Published:
7/2023

A Miniaturized, Battery-Free, Wireless Wound Monitor That Predicts Wound Closure Rate Early

Cronic wounds, diabetic ulcers, lactate sensing, wireless electronics

Diabetic foot ulcers are chronic wounds that affect millions and increase the risk of amputation and mortality, highlighting the critical need for their early detection. Recent demonstrations of wearable sensors enable real-time wound assessment, but they rely on bulky electronics, making them difficult to interface with wounds. Herein, a miniaturized, wireless, battery-free wound monitor that measures lactate in real-time and seamlessly integrates with bandages for conformal attachment to the wound bed is introduced. Lactate is selected due to its multifaceted role in initiating healing. Studies in healthy and diabetic mice reveal distinct lactate profiles for normal and impaired healing…



Fabrication of Lactate Sensor: Electron beam evaporation (AJA International Inc., MA, USA) formed a thin film of chromium (thickness, 10 nm) as an adhesion layer, followed by a layer of gold (Au; thickness, 100 nm) as a conductor on a 75-mm thick sheet of polyimide (PI; Argon Inc., CA, USA). A UV laser (ProtoLaser U4, LPKF Laser & Electronics, Germany) patterned the gold-coated polyimide sheet to define the separate anode and cathode circular active areas, interconnects, and contact pads.
Fabrication of Wireless Electronic Module: Laser ablation processing (ProtoLaser U4, LPKF Laser & Electronics, Germany) fabricated flexible printed circuit boards (fPCBs) from commercial double-sided laminated copper (18 µm)–polyimide (75 µm)–copper (18 µm) multi-layer stacks (Pyralux AP8535R,…

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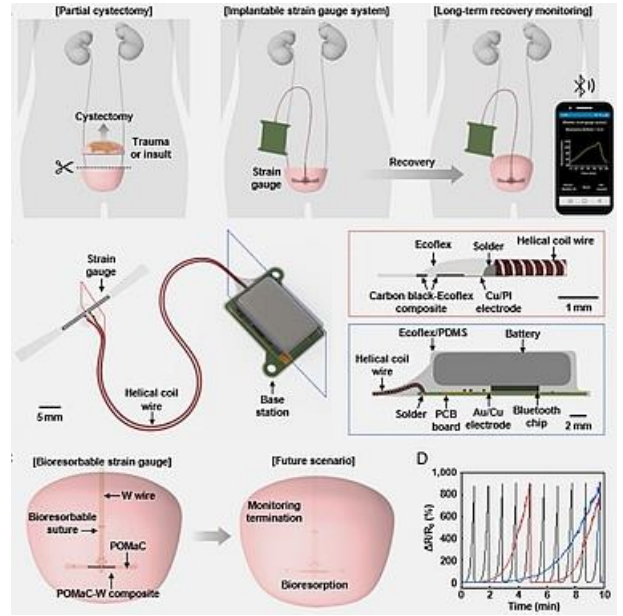
https://onlinelibrary.wiley.com/doi/10.1002/adhm.202301280

A wireless, implantable bioelectronic system for monitoring urinary bladder function following surgical recovery

Bladder, regeneration, bioelectronics, wireless, sensing

Partial cystectomy procedures for urinary bladder–related dysfunction involve long recovery periods, during which urodynamic studies (UDS) intermittently assess lower urinary tract function. However, UDS are not patient-friendly, they exhibit user-to-user variability, and they amount to snapshots in time, limiting the ability to collect continuous, longitudinal data. These procedures also pose the risk of catheter-associated urinary tract infections, which can progress to ascending pyelonephritis due to prolonged lower tract manipulation in high-risk patients. Here, we introduce a fully bladder-implantable platform that allows for continuous, real-time measurements of changes in mechanical..



Fabrication of the Bladder Monitoring System. The fabrication process for the strain gauge involved attaching a polyvinyl-alcohol (PVA) film (50 µm, Ruimao) on a glass substrate (1 mm, Fisher brand) with PI tape (KPT-1/4, Bertech), spin-coating a silicone elastomer (Ecoflex 00-30, Smooth-On) at 2,000 rpm for 30 s, attaching a Cu/PI (9 µm/12 µm) electrode, and annealing on a hot plate at 110 °C for 60 s. After screen-printing a carbon black (Vulcan XC 72R, Fuel Cell Store) doped silicone elastomer (22.5 wt%) through a PI mask (75 µm, American Durafilm) and … A mask of PDMS (thickness ~1 mm) covered the Cu/PI electrode …. An ultraviolet laser prototyping system (LPKF Laser & Electronics) cut the outline of the strain gauge.

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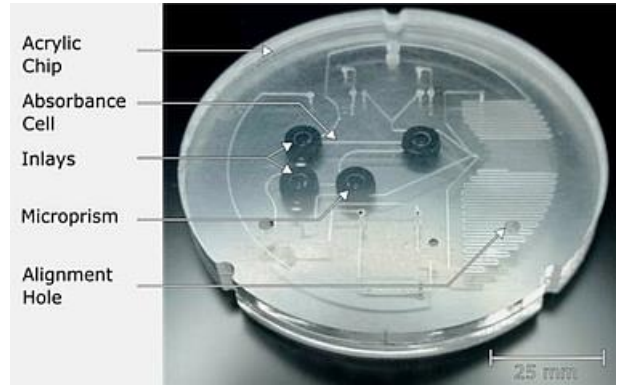
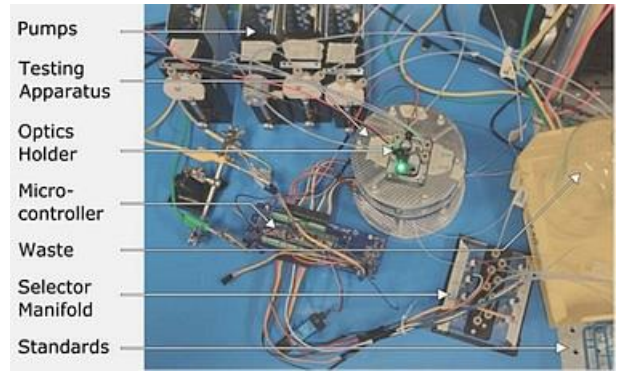
https://rogersgroup.northwestern.edu/files/2024/bladder.pdf

Continuous Flow with Reagent Injection on an Inlaid Microfluidic Platform Applied to Nitrite Determination

microfluidics, ocean sensors, nitrite, lab on chip, environmental monitoring

A continuous flow with reagent injection method on a novel inlaid microfluidic platform for nitrite determination has been successfully developed. The significance of the high-frequency monitoring of nutrient fluctuations in marine environments is crucial for understanding our impacts on the ecosystem. Many in-situ systems face limitations in high-frequency data collection and have restricted deployment times due to high reagent consumption. The proposed microfluidic device employs automatic colorimetric absorbance spectrophotometry, using the Griess assay for nitrite determination, with minimal reagent usage. The sensor incorporates 10 solenoid valves, …





Before milling in the surface features and through holes, the entire sheet was back-planed down by 0.3 mm using a micromill (S103, LPKF Laser & Electronics, Garbsen, Germany) to ensure that the two faces were parallel. Next, the sheet was transferred to a similar micromill (S104, LPKF Laser & Electronics, Garbsen, Germany) and the channels and absorbance cells were created using a 500 µm flat-end mill, with a prescribed depth of 500 µm. A 45-degree endmill was used to engrave the microprisms at either end of the absorbance cells, within the aperture created by the opaque inlays, cut to 0.8 mm deep. After each face of the acrylic sheet had been milled and all the features created, the sheet was transferred back to the laser cutter and the chip halves were cut out from the

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LPKF ProtoMat S103

Material used: **RO4, RO3003**

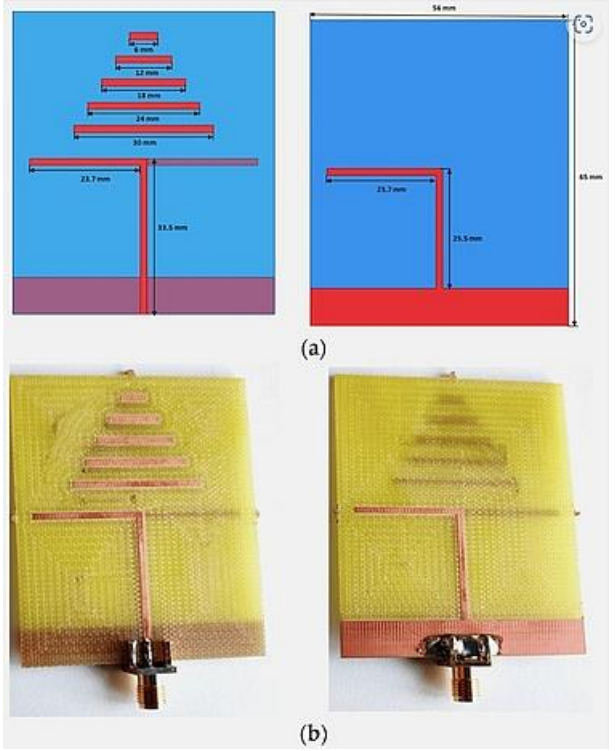
Application area: **RF Antenna (WiFi)**

Published: **05/2023**

High Gain Improved Planar Yagi Uda Antenna for 2.4 GHz Applications and Its Influence on Human Tissues

dielectric; S parameters; gain; SAR; electric field; magnetic field

Considering the technological enhancements nowadays, antennas tend to be smaller in order to be easily integrated in devices. The most used antennas today in small high-tech devices close to the human body are planar antennas. In this paper, a Yagi Uda planar antenna operating at a frequency of 2.4 GHz is HF analyzed and optimized by increasing its bandwidth and gain while maintaining its initial dimensions. The methods used to optimize the antenna's operation are the use of different dielectrics, different numbers of directors, and different dimensions for directors, placing new conductor elements, all while keeping the same dimensions for its implementation on the planar …



The initial structure from which this analysis begins is presented in Figure 1, and it is the result of some studies previously published by the authors in [7]. The antenna is constructed on an FR4 epoxy substrate with the relative permittivity of 4.4 and a thickness of 1.51 mm. On one side of the dielectric, there are the 5 directors, while on the other side, there is the reflector. The distance between the feeding dipole and the first director is 5.5 mm, while between the directors, the distance is maintained constant at 3.5 mm. The antenna was constructed with the LPKF ProtoMat S103 Plotter (Figure 2) by importing the geometry designed in the ANSYS High Frequency Software Simulator (HFSS) module to the dedicated design software for the plotter, LPKF Circuit Pro.

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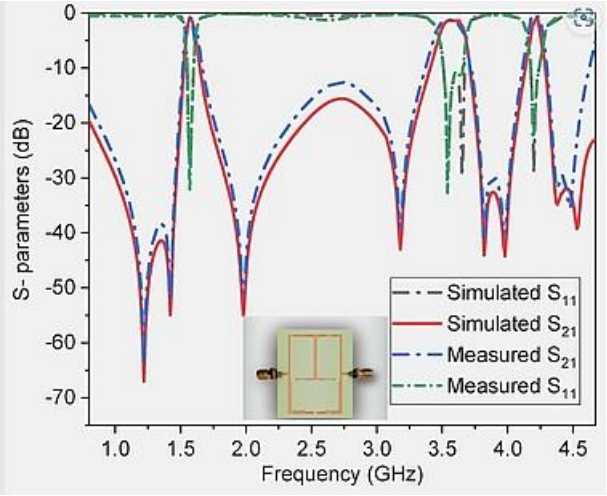
https://www.mdpi.com/2076-3417/13/11/6678

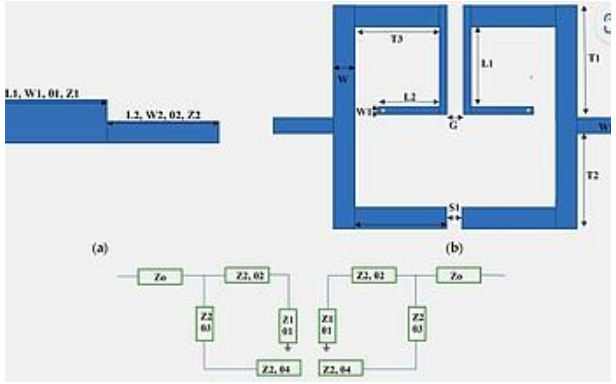
Design and Modelling of a Compact Triband Passband Filter for GPS, WiMAX, and Satellite Applications with Multiple Transmission Zero's

L-shaped resonator, transmission zeros, triband filter, wireless applications

Designing microwave filters with high selectivity and sharp roll-off between the stop and pass bands can be challenging due to the complex nature of the R.F. signals and the requirements for achieving high performance in a limited physical space. To achieve a high selectivity and sharp roll-off rate, this paper presents a compact filter with a triple passband response. The two different passbands at 1.57 GHz and 3.5 GHz are achieved using a step impedance resonator (SIR) with metallic slots perturbation added to the lower corner of the high impedance section of the SIRs, which helps to enhance the filter's selectivity and size reduction greatly. The embedded L-shaped structure …

The first two passbands at 1.57 GHz and 3.57 GHz are obtained due to the coupled λ/4 SIR for GPS and WiMAX wireless applications, and the third passband at 4.23 GHz is obtained due to the embedded coupled L-shaped structure for satellite communication. All the resonators are folded to introduce coupling and sharpness in the filter by exciting multiple transmission zeros between the passbands. There is a total of eight T.Z.s excited at different locations, i.e., 1.22, 1.42, 1.98, 3.18, 3.82, 3.98, 4.38, and 4.53 GHz. After simulating the proposed filter in HFSS software, it is fabricated on substrate RO-4350 using milling machine LPKF S63 ProtoLaser and tested on ZNB-20 VNA.





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https://www.mdpi.com/2504-3110/7/7/511

LPKF ProtoLaser U3

Material used: **LCE, MRE**

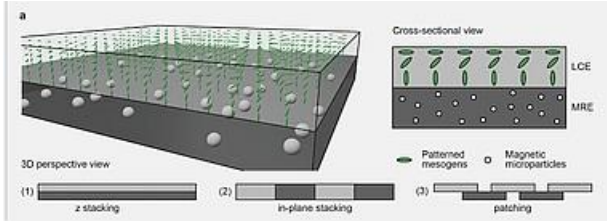
Application area: **Material research**

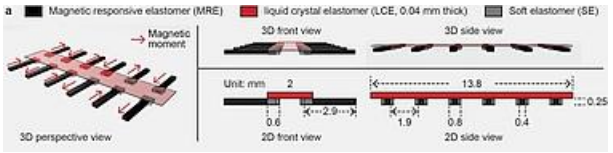
Published: **05/2021**

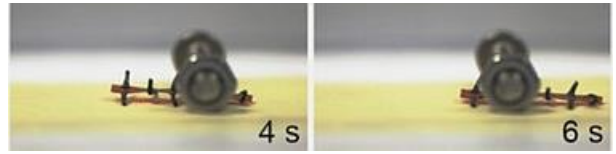
Wirelessly Actuated Thermo- and Magneto-Responsive Soft Bimorph Materials with Programmable Shape-Morphing

Soft materials, smart materials, shape-morphing, miniature robot

Soft materials that respond to wireless external stimuli are referred to as “smart” materials due to their promising potential in real-world actuation and sensing applications in robotics, microfluidics, and bioengineering. Recent years have witnessed a burst of these stimuli-responsive materials and their preliminary applications. However, their further advancement demands more versatility, configurability, and adaptability to deliver their promised benefits. Here, a dual-stimuli-responsive soft bimorph material with three configurations that enable complex programmable 3D shape-morphing is presented. The material consists of liquid crystal elastomers (LCEs) and …







Bimorph Materials

The reported bimorph material with various integration configurations was prepared by placing LCEs in the modes prior to the casting of MREs or on top of the casted MREs. The curing of MREs formed a bond between LCEs and MREs. Devices were made of the material via laser cutting (ProtoLaser, LPKF Laser & Electronics AG) according to designs made in a software (AutoCAD, Autodesk Inc.). A magnetization profile was then programmed into the device by deforming it and magnetizing it in a strong magnetic field (1.8 T) generated by a VSM (EZ7, Microsense).

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