Publications with LPKF equipment

Selection of internationally published scientific articles using LPKF equipment

September 2024

LPKF
Laser & Electronics

TOC: page, system, application

LPKF ProtoLaser R4

Material used:
ITO on PET, Pyralux AP8535R

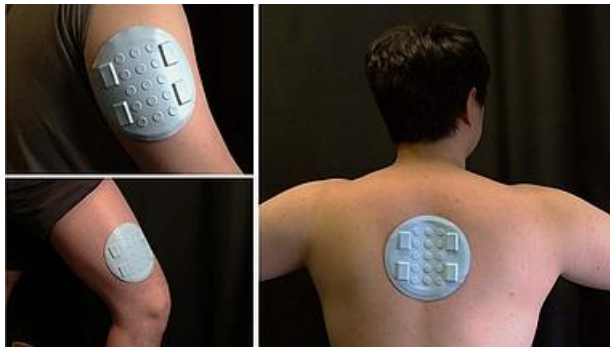
Application area:
Wearables

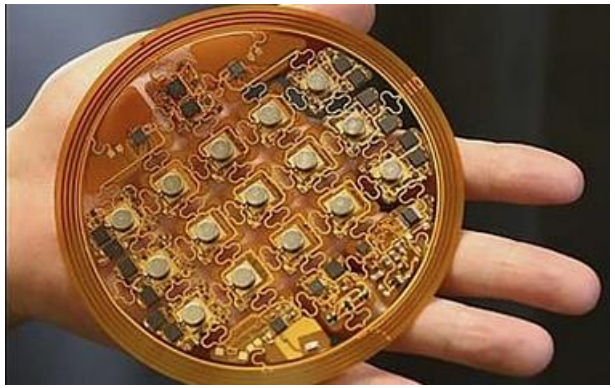
Published:
05/2024

A wirelessly programmable, skin-integrated thermo-haptic stimulator system for virtual reality

thermo-haptic stimulator

Sensations of heat and touch produced by receptors in the skin are of essential importance for perceptions of the physical environment, with a particularly powerful role in interpersonal interactions. Advances in technologies for replicating these sensations in a programmable manner have the potential not only to enhance virtual/augmented reality environments but they also hold promise in medical applications for individuals with amputations or impaired sensory function. Engineering challenges are in achieving interfaces with precise spatial resolution, power-efficient operation, wide dynamic range, and fast temporal responses in both thermal and in physical …





Fabrication and Integration of Temperature Sensors into a Touch Screen and Robot Hand. The transparent temperature sensor array designed for integration into the touch screen application used 15 resistive temperature sensors, each with dimensions of 10.5 × 15 mm2, and interconnects formed in a coating of Indium Tin Oxide (ITO) on a sheet of polyethylene terephthalate (PET, 639303, Sigma-Aldrich) patterned by laser ablation (**ProtoLaser R4**, LPKF Laser & Electronics). Each sensor mechanically and electrically connects to a corresponding pin of a board-to-board connector (527451633, Molex) soldered on top of a fPCB (W153849ASS48, Xinyang). The board-to-board connector served as an interface to the main electronic system of a BLE SoC, m-ADCs, and DC–

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

LPKF ProtoLaser R4

Material used:
PZT, Ag, PDMS
DuPont AC0925

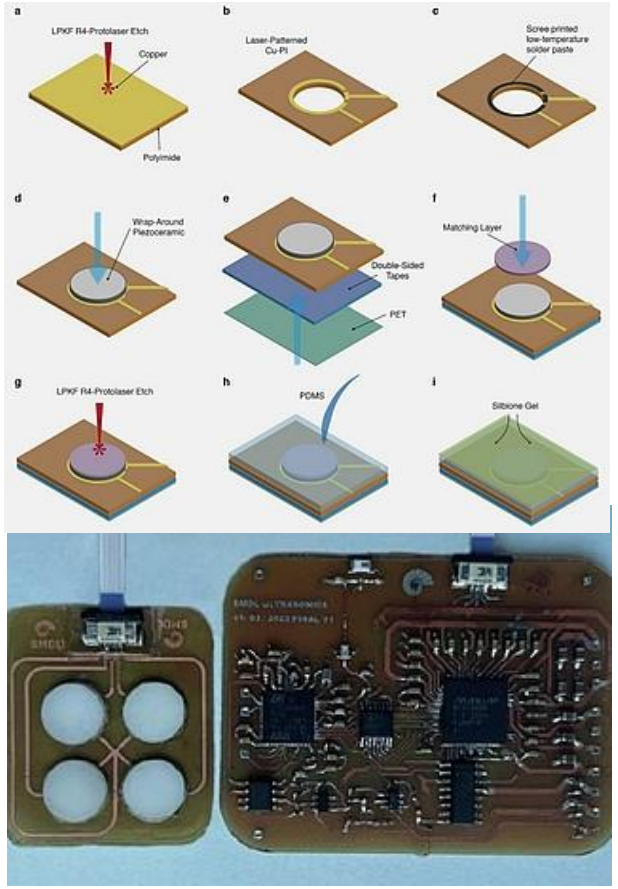
Application area:
Wearable sensor

Published:
8/2024

LPKF Laser & Electronics

An integrated and flexible ultrasonic device for continuous bladder volume monitoring

Wearable medical sensor, wearable ultra-sound measurement, bladder volume monitoring



Bladder volume measurement is critical for early detection and management of lower urinary tract dysfunctions. Current gold standard is invasive, and alternative technologies either require trained personnel or do not offer medical grade information. Here, we report an integrated wearable ultrasonic bladder volume monitoring device for accurate and autonomous continuous monitoring of the bladder volume. The device incorporates flexible and air-backed ultrasonic transducers and miniaturized control electronics with wireless data transmission capability. We demonstrate the real-life application of the device on healthy volunteers with various bladder shapes and sizes with high accuracy.

Fabrication of the UBVM device: Bulk PZT disks were purchased from American Piezo (APC-850). To enable access to top and bottom electrodes from the same plane, disks were modified to a custom wrap-around electrode configuration. A commercial picosecond-pulsed laser ablation system (Supplementary Fig. 12); 500 kHz pulse repetition frequency with a divider of 3, 1.5 W power and 1500 mm s−1 laser cutting speed, **R4, LPKF Laser & Electronics**) was utilized to isolate a small portion of the silver electrode on one face of the PZT disc. Then, the isolated portion of the silver electrode on that face was electrically connected to the electrode on the opposite face of the disc using a low-temperature silver paste (PE827, DuPont).

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https://www.nature.com/articles/s41467-024-50397-8

Implantable, Bioresorbable Radio Frequency Resonant Circuits for Magnetic Resonance Imaging

biomedical implants, bioresorbable implantable coil, BIC, magnetic resonance imaging, radiofrequency coils

Magnetic resonance imaging (MRI) is widely used in clinical care and medical research. The signal-to-noise ratio (SNR) in the measurement affects parameters that determine the diagnostic value of the image, such as the spatial resolution, contrast, and scan time. Surgically implanted radiofrequency coils can increase SNR of subsequent MRI studies of adjacent tissues. The resulting benefits in SNR are, however, balanced by significant risks associated with surgically removing these coils or with leaving them in place permanently. As an alternative, here the authors report classes of implantable inductor–capacitor circuits made entirely of bioresorbable organic and inorganic materials.

Fabricating the BICs: The fabrication began with spin-coating (4000 rpm for 1 min) of a solution of PVA (Mw 13 000–23 000, Sigma-Aldrich; 20 wt% in water) on a 50 µm thick Mo foil, followed by laser cutting (**ProtoLaser U4**, LPKF Laser & Electronics) into an electrically connected pattern composed of one planar coil (square layout, 1 turn, 7 mm wide, 7 mm long, 200 µm in trace width) and two plates (≈42 mm2 area for each) for the inductor and capacitor, respectively. Overlapping the plates allowed insertion of a PLGA (65:35 [lactide:glycolide], Mw 40 000–75 000, Sigma-Aldrich) film (35 µm thick) in between. The PLGA film, bonded to these plates by hot-pressing (≈70 °C) for 2 min, to form an insulating layer in a parallel plate capacitor configuration. Embedding the entire sample into an encapsulating structure of …

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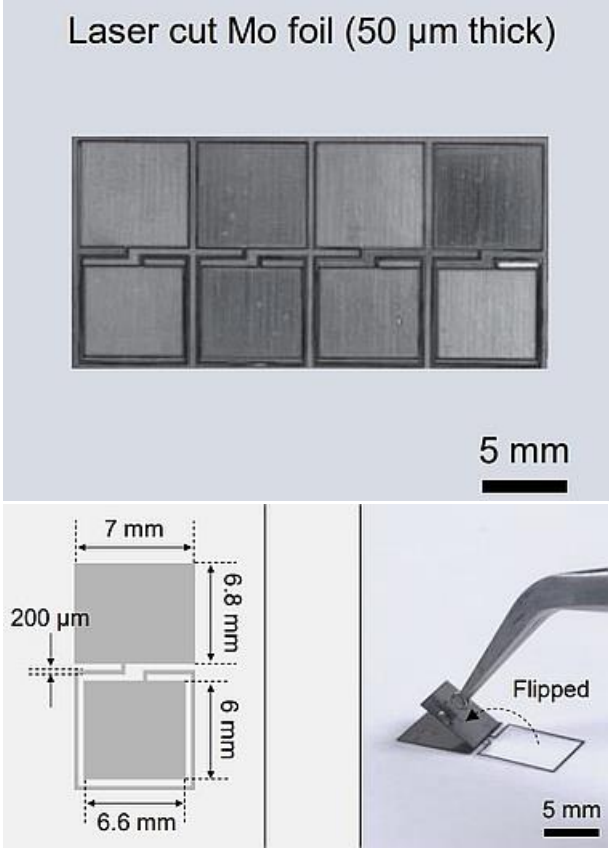
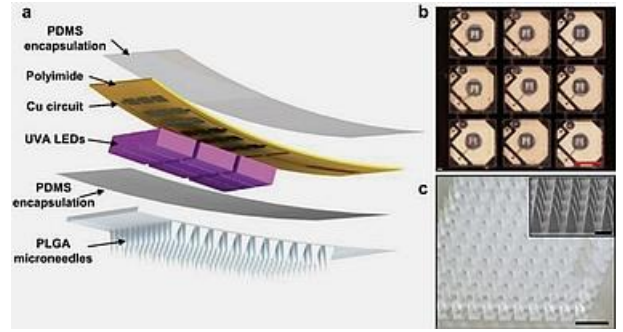
https://onlinelibrary.wiley.com/doi/10.1002/advs.202301232



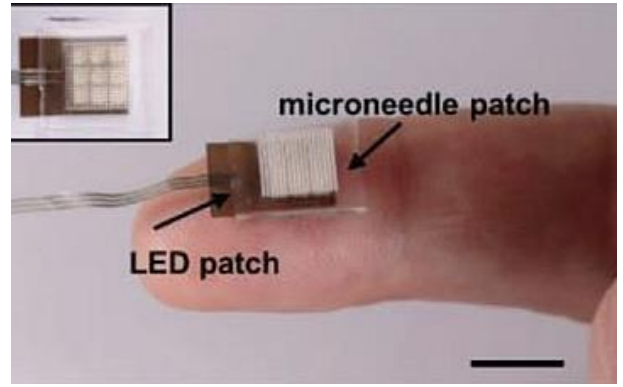
Biocompatible Light Guide-Assisted Wearable Devices for Enhanced UV Light Delivery in Deep Skin

biocompatible microneedles, light waveguides, skin phototherapy, wearable devices

Phototherapy represents an attractive route for treating a range of challenging dermatological diseases. Existing skin phototherapy modalities rely on direct UV illumination, although with limited efficacy in addressing disorders of deeper tissue and with requirements for specialized illumination equipment and masks to shield unaffected regions of the skin. This work introduces a skin-integrated optoelectronic device that incorporates an array of UVA (360 nm) light emitting diodes in layouts that match those of typical lesional plaques and in designs that couple to biocompatible, penetrating polymer microneedle light waveguides to provide optical access to deep skin.



Fabrication of UVA LED Arrays: Copper-clad polyimide laminates (18 μm copper/75 μm polyimide/18 μm copper, DuPont Pyralus AP8535R) served as substrates for flexible printed circuit boards. Laser ablation (**LPKF4 UV** laser system) defined the conductive traces, pads, and outlines of the devices. Surface-mounted UVA LEDs with peak emission at ≈360 nm (1.6 × 1.6 × 1.4 mm, VLMU1610-365-135, Digikey) were assembled and mounted on the printed circuit boards by low temperature reflow soldering. A dip-coated layer of cured PDMS (thickness < 100 μm) encapsulated the devices. Flexible anisotropic conductive film (ACF) cable, together with a custom printed circuit board, connected the devices to an external power source (Keithley 6220).



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https://rogersgroup.northwestern.edu/files/2021/adfmmicroneedles.pdf

LPKF ProtoLaser U4

Material used:
MA–MA, MA-UDMA Acrylate-IBA

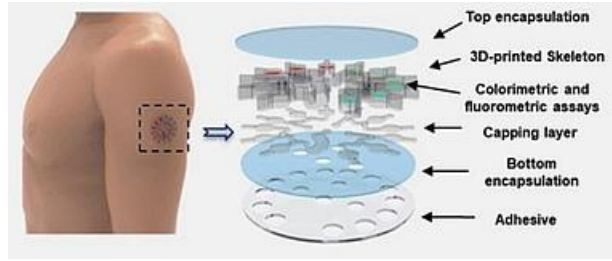
Application area:
Wearable medical sensor

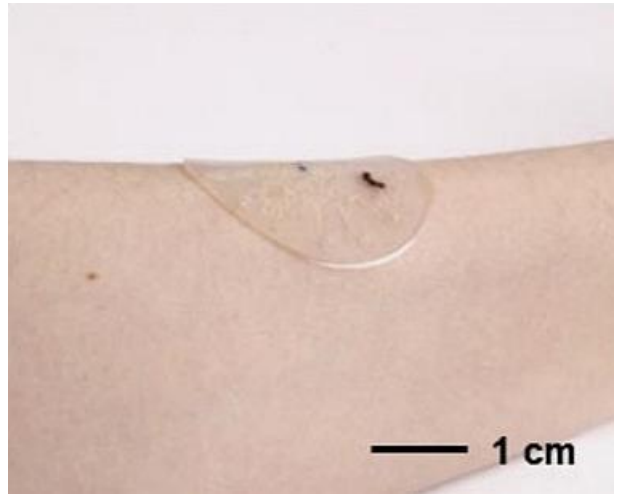
Published:
08/2023

3D-printed epidermal sweat microfluidic systems with integrated microcuvettes for precise spectroscopic and fluorometric biochemical assays

microfluidics, microcuvettes,

Systems for capture, storage and analysis of eccrine sweat can provide insights into physiological health status, quantify losses of water, electrolytes, amino acids and/or other essential species, and identify exposures to adverse environmental species or illicit drugs. Recent advances in materials and device designs serve as the basis for skin-compatible classes of microfluidic platforms and in situ colorimetric assays for precise assessments of sweat rate, sweat loss and concentrations of wide-ranging types of biomarkers in sweat. This paper presents a set of findings that enhances the performance of these systems through the use of microfluidic networks, integrated valves …





The soft and elastic properties of the Acrylate-IBA facilitates demolding from a UV curable optical adhesive (NOA63, Norland Products Inc., NJ, USA), selected as the skeletal material for its high transparency (Average of 500–700 nm: 90.6%), low fluorescence background intensity (Fig. S11, ESI†), and high modulus (Young's modulus: 1.1 GPa). An ultraviolet laser system (**ProtoLaser U4**, LPKF, Germany) removes excess materials and defines the overall profile the molded structure. As with the 3D printed examples, these molded parts can be loaded with chemical assays, capped with adhesives and encapsulated in PDMS to yield complete devices.

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https://pubs.rsc.org/en/content/articlelanding/2023/mh/d3mh00876b

LPKF ProtoLaser U4

Material used:
Dupont Pyralux AP8535R

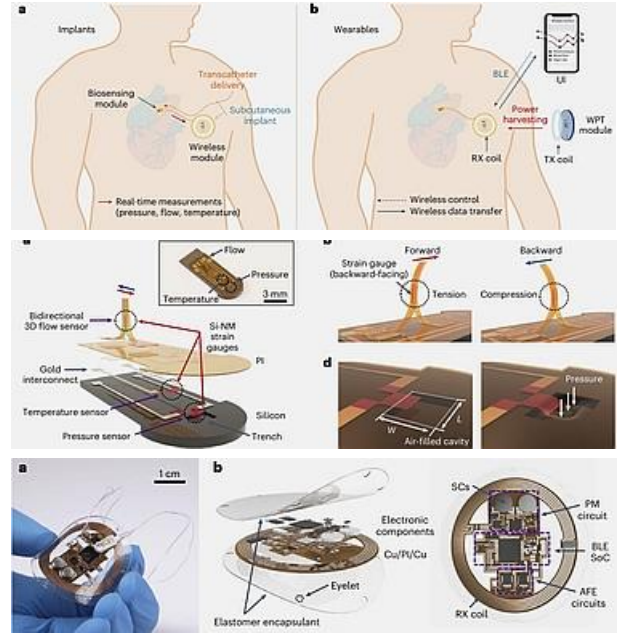
Application area:
Implantable medical sensors

Published:
04/2023

A battery-less wireless implant for the continuous monitoring of vascular pressure, flow rate and temperature

real-time haemodynamics, wireless power, wireless data, biocompatible

Devices for monitoring blood haemodynamics can guide the perioperative management of patients with cardiovascular disease. Current technologies for this purpose are constrained by wired connections to external electronics, and wireless alternatives are restricted to monitoring of either blood pressure or blood flow. Here we report the design aspects and performance parameters of an integrated wireless sensor capable of implantation in the heart or in a blood vessel for simultaneous measurements of pressure, flow rate and temperature in real time. The sensor is controlled via long-range communication through a subcutaneously implanted and wirelessly powered Bluetooth Low…



Fabrication of the wireless electronics module A Cu/PI/Cu film (AP8535R, Pyralux, DuPont) served as a thin (thicknesses of 18 µm/75 µm/18 µm), flexible substrate. An ultraviolet laser cutter **ProtoLaser U4**, LPKF) processed the substrate to define antenna coils, circuit traces, bond pads, and through-hole vias, resulting in a flexible printed circuit board. A conductive silver paint (cat. no. Z05001, SPI Supplies) created electrical connections between the top and bottom layers of the board through vias when heated at 90 °C using a hot air gun (AOYUE Int866).
Fabrication of flow sensor: After removal of the top Cu layer via wet etching, an ultraviolet laser (**ProtoLaser U4**, LPKF) defined the border outline.

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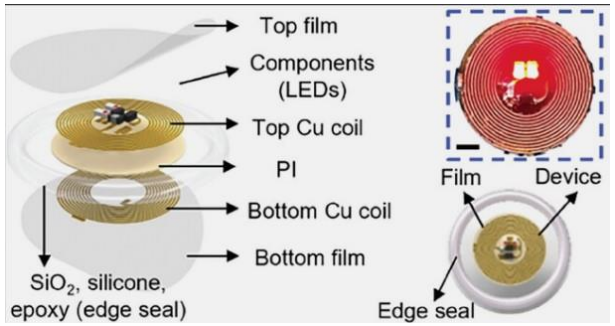
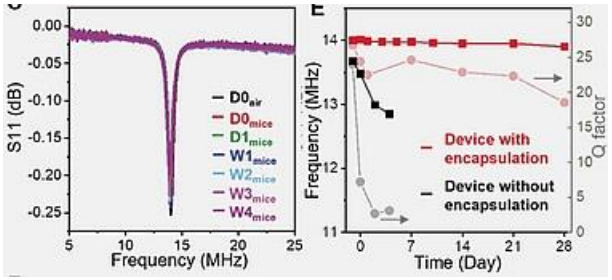
https://rogersgroup.northwestern.edu/files/2023/nbmepress.pdf

Bioresorbable Multilayer Organic–Inorganic Films for Bioelectronic Systems

Bioresorbable electronic, SION-PA

Bioresorbable electronic devices as temporary biomedical implants represent an emerging class of technology relevant to a range of patient conditions currently addressed with technologies that require surgical explantation after a desired period of use. Obtaining reliable performance and favorable degradation behavior demands materials that can serve as biofluid barriers in encapsulating structures that avoid premature degradation of active electronic components. Here, this work presents a materials design that addresses this need, with properties in water impermeability, mechanical flexibility, and processability that are superior to alternatives.





Fabrication: The implantable LED devices used designs modified from flexible near-field wireless optoelectronic systems reported previously for optogenetics applications.[49] The device consisted of two circular Cu coils (diameter: 6 mm,10 turns; thickness: 18 µm; dielectric layer: 75-µm polyimide) with surface-mounted electronic components for power transfer. Power transfer uses magnetic coupling to a separate RF transmission loop antenna or a wireless powering system operating at 13.56 MHz. Device fabrication began with patterning a flexible substrate made of a copper–PI–copper laminate (Pyralux, DuPont, USA) using laser ablation (LPKF, **ProtoLaser U4**, Germany) to define the circuit interconnects and the bonding pads for the electronic components.

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https://onlinelibrary.wiley.com/doi/10.1002/adma.202309421

LPKF ProtoLaser U4

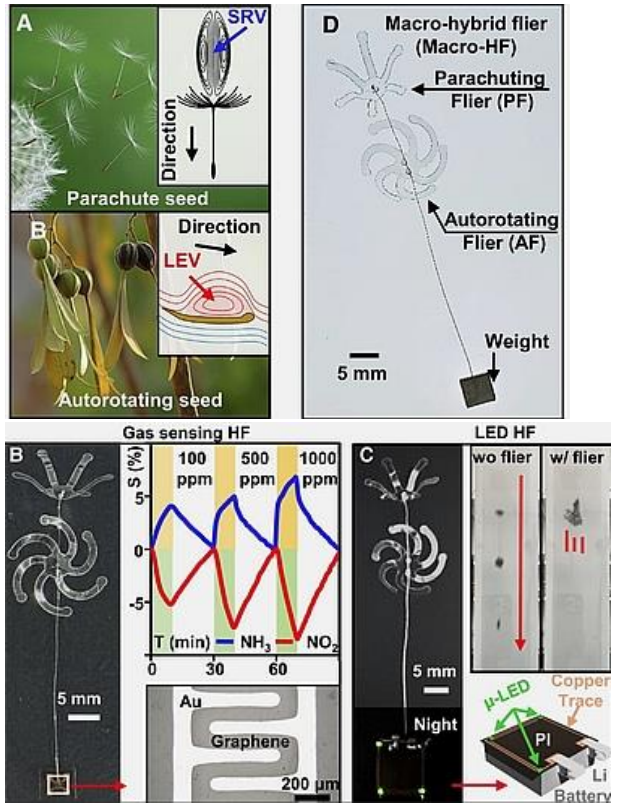
Material used:
PLGA, Dupont Pyralux AP8535R

Application area:
Passive flying system

Published:
03/2024

Functional bio-inspired hybrid fliers with separated ring and leading edge vortices

bio-inspired design, aerodynamics, fluid mechanics, 3D fabrication, soft electronics



Recent advances in passive flying systems inspired by wind-dispersed seeds contribute to increasing interest in their use for remote sensing applications across large spatial domains in the Lagrangian frame of reference. These concepts create possibilities for developing and studying structures with performance characteristics and operating mechanisms that lie beyond those found in nature. Here, we demonstrate a hybrid flier system, fabricated through a process of controlled buckling, to yield unusual geometries optimized for flight. Specifically, these constructs simultaneously exploit distinct fluid phenomena, including separated vortex rings from features that resemble those of dandelion…

Fabrication and measurement of the LED HF: Pyralux AP8535R served as a substrate for the circuit. The top copper layer (17.5 µm thick) and traces for the LED (0.65 mm × 0.35 mm × 0.2 mm) were structured via direct laser ablation (**LPKF U4**). Hot-air soldering using low-temperature solder 637 (Indium Corp., Clinton, NY) bonded LEDs (Green 571 nm LED, Digi-Key Electronics, MN) to the respective pads. An ultralow-weight lithium-ion battery (0.33 g, 3 mm × 9 mm × 10 mm, PowerStream Technology, UT) supplied power to the LED.

Fabrication of 2D precursors in PLGA began with laser ablation to define shape selected based on …

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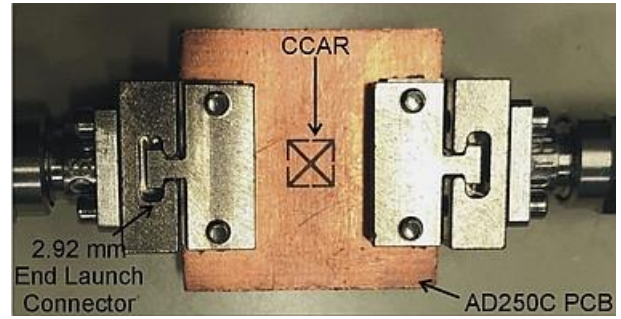
https://academic.oup.com/pnasnexus/article/3/3/pgae110/7625212

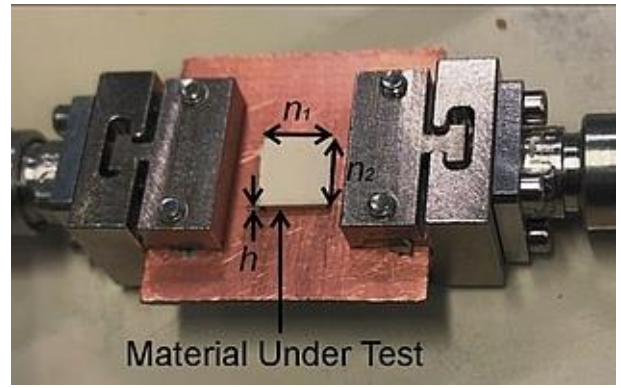
New Complementary Resonator for Permittivity- and Thickness-Based Dielectric Characterization

complementary crossed arrow resonator; design optimization; inverse modeling dielectric characterization; permittivity

The design of high-performance complementary meta-resonators for microwave sensors featuring high sensitivity and consistent evaluation of dielectric materials is challenging. This paper presents the design and implementation of a novel complementary resonator with high sensitivity for dielectric substrate characterization based on permittivity and thickness. A complementary crossed arrow resonator (CCAR) is proposed and integrated with a fifty-ohm microstrip transmission line. The CCAR's distinct geometry, which consists of crossed arrow-shaped components, allows for the implementation of a resonator with exceptional sensitivity to changes in permittivity and thickness…



Fabrication and Experimental Validation: This section investigates the fabrication process of the optimized sensor and the subsequent measurements conducted using selected dielectric samples. The optimized CCAR sensor has been fabricated using the LPKF **Protolaser** on an AD250C printed circuit board (PCB), cf. Figure 7. The LPKF ProtoLaser machine employs laser technology, specifically a scanner-guided laser operating at a wavelength of **355 nm** within the ultraviolet (UV) spectrum. This laser is utilized to selectively eliminate material, such as copper (in our case 18 µm), from the surface of a PCB in order to generate the sensor layouts. The dimensions of the constructed prototype are consistent with those outlined in the previous section.



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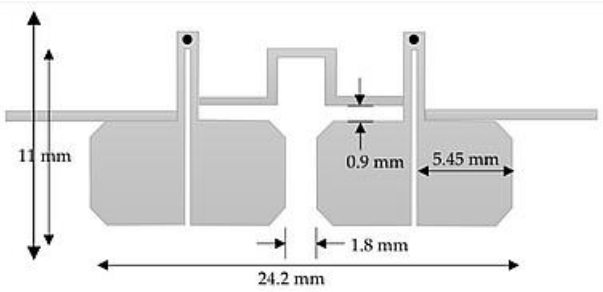
https://www.mdpi.com/1424-8220/23/22/9138

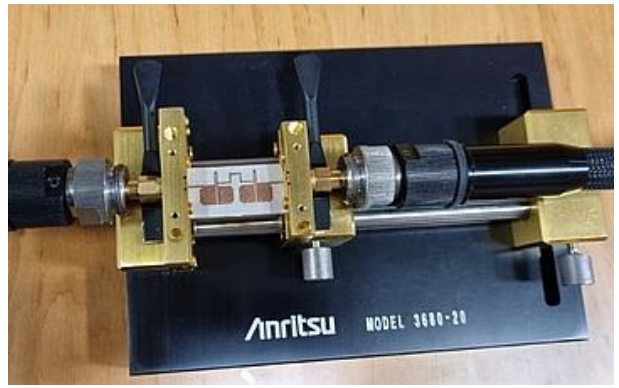
A New Compact Wideband Filter Based on a Coupled Stepped Impedance Resonator

SIR filter, quarter-wavelength resonator, quarter-wavelength SIR, microstrip technology

A new compact wideband filter is introduced to address the requirements of recent communication and radar systems. The filter is based on a quarter-wavelength short-circuit coupled stepped impedance resonator (SIR). The analytical solution shows that the suggested SIR resonator provides a compact size and a wide stopband response, which are essential features in many wireless communication systems. The analytical results also reveal that increasing the impedance ratio of the SIR extends the stopband by increasing the first spurious response and reducing its total length. A compact two-coupled short-circuit SIR filter is designed at 1.23 GHz. The design approach …



This circuit is implemented on the same substrate using the **LPKF Laser and Electronics**, Germany, machine with a minimum line width and separation between the line's capability of 50 µm. Figure 10 shows a photograph of the implemented filter. The size of the filter is 11 × 24.2 mm2. This significant size reduction of the four-resonator filter at 1.31 GHz is achieved by the selection of high dielectric constant material and the short-circuit stepped impedance resonator. The filter is experimentally characterized using the Vector Network Analyzer 37369C, and held in the test fixture 3680-20, both from Anritsu, Japan, as shown in Figure 11. The measurement results are shown in Figure 12. The measured 3-dB bandwidth is 390 MHz, centered at 1325 MHz (29.4% relative bandwidth).



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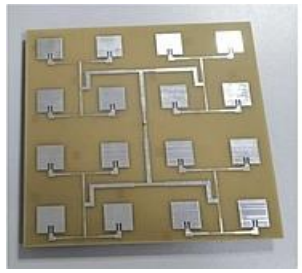
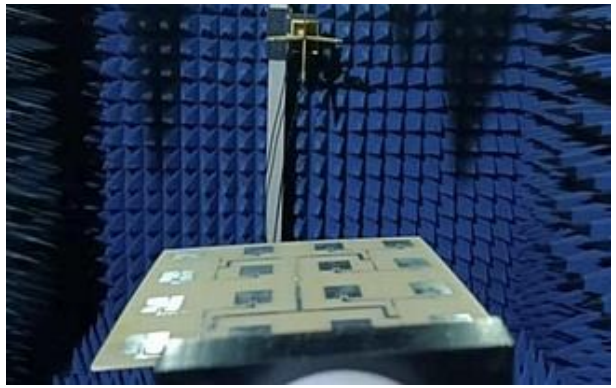
https://www.mdpi.com/2072-666X/15/2/221

Simulation and Design of Three 5G Antennas

5G communication; microstrip array antenna; MIMO array antenna; miniaturization; high isolation



In the context of 5G networks, this paper investigates microstrip array antennas and mobile terminal MIMO array antennas. It introduces two innovative designs and, based on these, develops and fabricates a mobile terminal antenna. The first of these designs, a 4 × 4 microstrip array antenna operating in the LTE band 42 (3.4–3.6 GHz), is researched and fabricated and an innovative approach, combining embedded and coaxial feeding methods, is proposed and employed. Measurement results indicate a bandwidth of 373 MHz (3.321–3.694 GHz), achieving a relative bandwidth of 10.7%. The antenna exhibits a high gain of 12.7 dBi, with an undistorted radiation…



Fabrication of a 4×4 Array Antenna Prototype

In this design project, the fabrication and soldering of the array antenna were carried out entirely within the laboratory. The process involved the use of the **ProtoLaser ST** series products from LPKF, in conjunction with the CircuitPro PL software-driven system. To achieve the best experimental results and to simultaneously fabricate multiple array antenna boards, manual soldering of the feeding SAM connectors was performed. Figure 21 presents the physical fabrication diagram of the array antenna, where Figure 21a provides an overview of the front side patch illustration and Figure 21b depicts the schematic representation of the rear side with feeding SAM connectors.

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https://www.mdpi.com/2076-3417/14/17/8032

LPKF ProtoMat S103

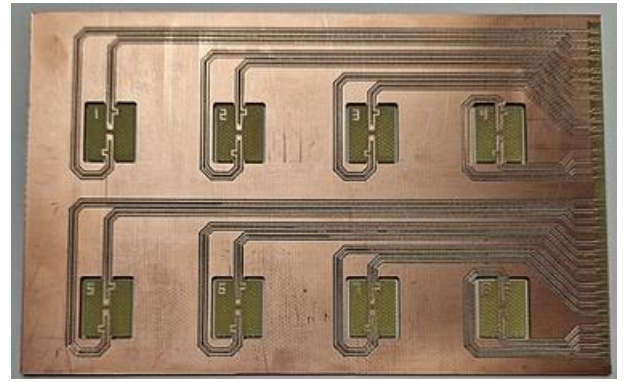
Material used: **FR4**

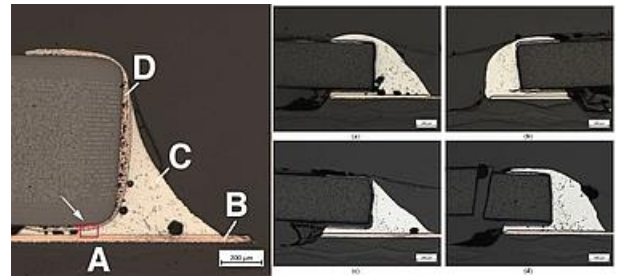
Application area: **Electronics reuse research**

Published: **08/2024**

The Effect of Multiple Solder Reflows on the Formation of Cu6Sn5 Intermetallics and the Decomposition of SnAg3.0Cu0.5 Solder Joints in the Framework of Rework and Reuse of MLCC Components

Cu6Sn5 intermetallic; intermetallic morphology; reflow; solder; SnAg3.0Cu0.5; multiple reflows; reuse; MLCC; shear test





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 …

The measurements have been carried out after every reflow cycle, up to a total of eight cycles. After machining the PCBs using a drilling machine, **ProtoMat S103** (LPKF, Garbsen, Germany), the oxide layers of the PCB surface were removed with a rough pad to allow proper wetting of the solder paste. A compressed air dispenser, DX-250 (OKI, Cypress, CA, USA), was used for the deposition of the paste onto the solder pads. In the final step, the MLCC components, which will be used for testing (samples), were placed with a manual pick-and-place system, **ProtoPlace S** (LPKF). The soldering process was made in an **N2** protective atmosphere using **LPKF’s batch reflow** oven with the accompanying software FlowShow (version 2.10) to record the temperature profiles of the….

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