Interfacial Liquid Film Transfer Printing of Versatile Flexible Electronic Devices with High Yield Ratio

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Emerging flexible electronic devices differ widely in terms of material, shape, scale, and structure. The conventional solid-contact stamp transfer printing method easily causes cracks and interfacial delamination in large-area, intricately-patterned multilayered devices. Liquid film transfer printing (LTP) is presented as a strategy to obtain flexible devices with a high yield ratio regardless of the device material, scale, shape, and structure. In this technique, the liquid film is used to hydrolyze and break the chemical bonds between the film and silicon wafer substrate. Thus, there is less stress on the device during the transfer process. In addition, the buoyancy and surface tension of the liquid film help the flexible device to unroll itself on the liquid surface. In the experiments, flexible devices of different types and with extreme properties consistently achieved a transfer printing yield ratio of 98.57%. The sensitivity of temperature sensor change before and after LTP is less than 2%. The real-time and visualized comparisons of the stress distribution and evolution during LTP and solid-contact methods demonstrated that the LTP maximum strain is 70% smaller than the latter method. Thus, LTP has great potential for sophisticated and system-level flexible device transfer printing and integration.

1. Introduction

Flexible electronics transcend conventional bulky and rigid electronic devices owing to their ease of use. They have shown tremendous potential for application in wearable health and fitness monitoring.[1–5] Various flexible electronics can intimately integrate with the human body and measure signals of different types. For mechanical signal monitoring, flexible strain sensors,[6,7] pressure sensors,[8,9] and sound sensors[10,11] can be used to measure vital signs such as pulse, heart rate, body temperature, and voice.[12,13] For electrical signal monitoring, flexible electrodes[14] can measure the electrocardiogram,[15,16] electroencephalogram,[17–19] electromyogram,[20] electrooculogram,[21] and electroneurogram.[22] For biochemical signal monitoring, flexible biosensors[23] can measure glucose,[24–26] ethanol,[27] lactate,[28] and other ions[29] in body fluids.

Flexible electronic devices are often designed as tattoo-like thin-film structures with very small thicknesses (few microns) to achieve high conformity and flexibility with the human skin.[30] The substrate and packaging materials are mainly polymers.[31–33] Conductive polymers and organic semiconductor materials are intrinsically soft, flexible, and easy to synthesize.[34] However, their performances are not comparable to those of metal and inorganic semiconductors such as, gold, silicon, and graphene.[35–37] To date, inorganic materials such as, metals and semiconductors have been the first choice for high-demand sensing situations. The common preparation methods for inorganic materials are epitaxial growth,[38] vapor deposition,[19] and inkjet printing.[40] During the fabrication process, to obtain high device integration and line precision, the fabrication, and patterning of the metal and semiconductor must be performed on the silicon wafer to guarantee the material quality and fabrication precision. After the deposition of the device material and fabrication processes on the silicon wafer, the thin-film device has to be peeled off from the wafer substrate and pasted onto a flexible substrate using the transfer printing method.

Several transfer printing methods have been developed for the peeling and pasting of thin-film flexible electronic devices. The most commonly used method, contact mode transfer printing, utilizes an elastic polydimethylsiloxane (PDMS) stamp.[41] In this process, the device is transferred by adjusting the interface strength.[42,43] To increase the transfer printing yield rate, different materials and structures have been used, such as stamps with reversible boundary tips,[44] temperature-response microstructures,[45] magnetically actuated microstructures,[46] gecko feet-like microstructures,[47] and stamps made of water response hydrogels.[48] For a better contact mode, Corbett et al.

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have used silicon dioxide as the sacrificial layer,\(^{(49)}\) while Frisbie et al. have utilized an intaglio mask to print inks.\(^{(50)}\) Roll-to-roll transfer uses a machine to achieve automatic transfer printing from the donor substrate to the receiving substrate.\(^{(51)}\) There are thermal transfer methods as well, in which the device detaches from the substrate by a thermal release tape\(^{(52)}\) and thermal mismatch caused by laser.\(^{(53,54)}\) Apart from solid contact transfer printing methods, other developed methods can be contactless. Researchers have used ferric chloride solution\(^{(55)}\) and bubbles produced by the redox reaction\(^{(56)}\) to push the device off the substrate. For multilayer devices, Feng et al. have utilized the evaporation of a liquid drop for transfer printing of small-area substrates. For multilayer devices, Feng et al. have utilized the evaporation of a liquid drop for transfer printing of small-area substrates. These optical inspections confirm that there is no micro damage or visible damage, or defect during after the entire transfer process. Different patterns were transfer printed on soft and curved substrates such as nails, fingers, eyes, furs, rubber tubes, and textures, as shown in Figure S4, Supporting Information, confirming the flexibility of the device after LTP.

Although there are many options for thin-film device transfer printing, they often suffer from certain drawbacks and narrow applicability. For contact mode transfer printing, the tools (usually PDMS stamps) are in direct contact with the device surfaces and press on them. Thus, the stamp may damage the fragile device during pick-up and printing processes. In the thermal method, heat often causes device damage and leads to malfunction. For the method with a sacrificial layer, the solubility of the layer depends on the temperature. High temperature and pressure conditions are required for the growth of complex flexible electronic materials. In addition, the fabrication of multilayer devices requires heating for several times. The sacrificial layer polymerizes under these conditions, making it difficult to dissolve in the solution and fail to release the film device. Other transfer methods require the assistance of flexible stamps or thermal release tapes, which further increase the complexity of the process. The liquid drop method can only achieve small-scale device transfer and is not suitable for reuse. For bubble assist method, it is not suitable for precision film transfer because of the pressure distribution on the device, which is caused by the hydrogen bubble. Method with liquid metal is a good method. However, currently the line width limit is about 100 \(\mu\)m, which is not suitable for devices of high precision.

In this study, we demonstrate that liquid film transfer printing (LTP) can overcome the drawbacks of the abovementioned transfer printing methods. During the entire LTP process, the flexible devices soak in the liquid with soft contact, avoiding pressure, temperature change, and evaporation-induced edge tension. Flexible devices can be completely transfer printed without any damage. This method has a high yield ratio and suits devices of different materials, patterns, and sizes.

2. Results and Discussion

2.1. Liquid Film Transfer Printing: Principle and Process

The operation process of the LTP is shown in Figure 1. The LTP procedure consists of four steps: releasing, planking, rinsing, and printing. The device was fabricated on a silicon wafer with the structure illustrated in Figure S1, Supporting Information. The liquid film releasing layer was made of spin-coated polymethyl methacrylate (PMMA) (3 \(\mu\)m). The device holding substrate is a layer of spin-coated polyimide (PI) (8.5 \(\mu\)m). Both PMMA and PI are functional materials. The devices were fabricated using microfabrication processes such as physical vapor deposition, lithography, wet-etching, and reactive ion etching. As illustrated in Figure 1, the device wafer was soaked in the AZ400K LTP solution. Unlike the conventional dissolution of the PMMA sacrificial layer, the PMMA release layer did not dissolve. Instead, PMMA lost its adhesion to the silicon wafer. This is because in the AZ400K developer alkaline environment, the silicon-oxygen chemical bonds (Si–O) between the silicon wafer and the deposited PMMA layer hydrolyze at the sub-nanometer scale so that the liquid film replaces the interfacial chemical bonds. Along with the hydroxylation process, the thin-film device gradually detached from the silicon substrate. We repeated the transfer process in other kinds of solutions, showing that the LTP can take place in alkali and acid but cannot be achieved in neutral conditions such as buffer solutions. These results confirm that the hydroxylation of chemical bonds is the main operating principle of LTP. After the device was completely detached from the substrate, the thin film ascended and floated on the solution surface because of buoyancy. On the liquid surface, the device automatically unfolds because of the significant surface tension, which prevented the device from curling or crimping, making it easier to be planked up and transferred. In the planking process, a temporary PDMS plank substrate was used because of its surface hydrophobicity. The PDMS plank approached the liquid surface and device from the bottom. Then, the plank was raised slowly to hold the device and remove it from the liquid, as illustrated in Figure 1d. The PDMS plank and the device were shallowly rinsed in deionized water to wash out the remaining transfer solutions. Once the temporary PDMS plank dipped into the water, the device immediately left PDMS owing to its hydrophobicity and water surface tension, floating on the water surface. The final receiving flexible substrate repeated the process shown in Figure 1e,d for passive printing of the device on it. Moreover, the liquid used in planking process can be changed. For the substrates that are vulnerable to water, we can consider ethanol as a planking situation. For those vulnerable to all kinds of liquid, we can use a reverse mold as the planking substrate and print the device to the final substrate. Figure 1e–h shows the photos of the entire LTP process of an array device. During the printing process, the receiving glass rod substrate picked up the device, which was printed to the glass rod by van der Waals force. The typical self-stretched process and optical microscope images of the patterns are shown in Figures S2 and S3, Supporting Information. These optical inspections confirm that there was no micro damage or visible damage, or defect during after the entire transfer process. Different patterns were transfer printed on soft and curved substrates such as nails, fingers, eyes, furs, rubber tubes, and textures, as shown in Figure S4, Supporting Information, confirming the flexibility of the device after LTP.
Limited by the stamp dimensions and functional procedures, conventional stamp transfer methods are only able to operate on small-area devices and show obvious shape orientations. The devices under the stamp edges and of large ratio aspects such as rods, ribbons, and wires, often cannot be successfully transferred owing to the stress concentration caused by the scale mismatch. The LTP method is a universal and uniform method that can prove useful in situations involving different aspect ratios, materials, shapes, and areas.

We conducted an experiment to transfer ribbon patterns with large-range aspect ratios to demonstrate the capability of LTP. We designed rectangular arrays with different aspect ratios (1:1–1:400), as shown in Figure 2a. These arrays were transferred by LTP, and the yield rate was recorded by optical inspections. The statistical results of the varied-pattern tests are shown in Table S1, Supporting Information; almost 100% successful transfer rate was achieved for patterns of all aspect ratios. The results show that LTP can avoid stress concentration-induced damage that often occurs in high-aspect ratio pattern devices. In addition to different patterns, LTP is also widely applicable to different materials. Nearly all the materials used...
in the micro-electro-mechanical system can be transferred successfully. As shown in Figure 2b, array patterns made of inert metals such as Cu, Cr, Au, and Ti were fabricated on the same substrate at the same scale. With LTP, more than 95% of the patterned materials were successfully transferred. For materials that could react with alkali and metal aluminum, for instance, we performed transfer printing after packaging the complete circuit to avoid damage by chemical reactions.

Previous studies on flexible devices such as pressure sensors, temperature sensors, and electrodes mostly rely on the intrinsic properties of the materials. These devices are designed with simple pattern elements, such as rectangles and circles. However, an increasing number of emerging device functions are not only implemented using certain materials but also with sophisticated planar patterns such as electromagnetic circuits, optical oscillating chambers, and surface acoustic wave devices. Irregular shapes, such as, polygons, stars, and hollow patterns, have become increasingly common. The contact mode stamp transfer causes extremely large stress concentrations on the sharp angles, hollows, and curves. These concentrated parts are easily damaged. In comparison, LTP is mild and soft during the releasing process, regardless of the device patterns. In Table 1, we show the statistical results of a series of patterns transferred by LTP, with optical images and success rates. The solid hexagon, solid pentagon, solid triangle, and solid square patterns all had a transfer success rate of more than 96%, most of which can be 100%. In our experiment, the success rate of the solid hexagram was \( \approx 98.1\% \) and that of the solid star was \( \approx 98.3\% \), and nearly all the patterns were successfully detached from the substrate owing to the soft and gentle procedure of liquid tension. While hollow patterns with large aspect ratios were damaged easily using conventional methods, with LTP, hollow square patterns and hollow hexagons had a transfer success rate of 98.7% and 99.5%, respectively. Even for sharp hollow patterns such as hollow triangles, stars, and hollow hexagons, the success rates reached as high as 100%, 98.3%, and 98.1%, respectively. The yield statistics of different shapes is present in Table S2, Supporting Information. Further tests focused on more complex patterns consisting of both sharp points and a large aspect ratio. We fabricated and transferred a circuit-like pattern and found that complex patterns can also be transferred successfully. To confirm that LTP is a universal method for complex microstructures, we continued by transferring number digits of different sizes (critical dimensions ranging from 10 \( \mu \)m to 10 mm), characters of the English, Japanese, French, Korean, and Chinese alphabets. The results show that all of the above could be transferred with 100% success rate regardless of their size. Additionally, we tried to transfer even larger patterns (\( \approx \text{cm scale} \)) such as cartoons (2 cm \( \times \) 4 cm) and radio frequency identification coils (4 cm \( \times \) 4 cm), and all these patterns were transferred successfully, as shown in Table 1. We also measure the linewidth and space change by optical microscope of some patterns and a circuit. Then, we have compared geometry of the sensor and spacing between arrays before and after transfer. The results are shown in Figure S5 and Table S3, Supporting Information, the average pattern geometry and spacing change are less than 1% before and after transfer.

### 2.3. Characterization of the Flexible Device after Liquid Film Transfer Printing

In addition to observing the integrity of the device under an optical microscope, the stability and variation of the device were measured. The results are shown in Table 1.

#### Table 1. Different pattern arrays that are liquid-transfer-printed and their yield rate.

| Pattern          | Liquid-transferred | Success ratio |
|------------------|--------------------|---------------|
| **Big size**     |                    |               |
| RFID coil        | Achieved           |               |
| Cartoon          | Achieved           |               |
| Circuit          | Achieved           |               |
| Ribbon           | Achieved           |               |
| **Solid geometry** |                   |               |
| Pentagon         | 98.7%              |               |
| Hexagon          | 96.4%              |               |
| Triangle         | 100%               |               |
| Square           | 100%               |               |
| **Hollow convex and sharp hollow** |            |               |
| Triangle         | 100%               |               |
| Hexagon          | 99.5%              |               |
| Hexagram         | 98.1%              |               |
| Star             | 98.3%              |               |
| **Character**    |                    |               |
| Japanese         | Achieved           |               |
| Chinese          | Achieved           |               |
| English          | Achieved           |               |
| Number           | Achieved           |               |
| **Hollow convex and sharp solid** |           |               |
| Square           | 98.7%              |               |
| Pentagon         | 97.9%              |               |
| Hexagram         | 98.1%              |               |
performance is another important index for evaluating the success rate of transfer printing. To confirm that the device maintained its performance after the transfer printing process, a comparative experiment was conducted. As shown in Figure 3, we fabricated a thin-film temperature sensor. The initial temperature recorded by the sensor was 20 °C. The sensor was placed in a liquid environment and a water bath was used to increase the surface temperature of the sensor film to 30 °C. The relative change in resistance and temperature rise was measured at the same time to calibrate the sensor with a temperature response of 0.00195/°C, as shown in Figure 3b. The sensor was then transferred to a glass cylinder with a radius of 3 cm using the LTP process, as shown in Figure 3a. The results show that the sensor had a temperature response of 0.00198/°C after being transferred to the cylinder by the LTP process. Figure 3b shows that the temperature resistance response of the sensor remained the same as before the LTP process. Thus, the sensor showed a good linear response to temperature, and the sensitivity difference between before and after transfer was ≈1.54%, which represents a minor error of 0.0154 °C in real per degree measurements.

2.4. Transfer Printing of Multilayer Devices

In addition to emerging functional devices based on structure and shape designs, researchers have gone further toward the fabrication of multi-functional, system-level, and highly-integrated flexible hybrid electronics. Therefore, transfer printing of multilayer devices is a critical but challenging field, as is shown in Figure S6, Supporting Information. For stamp-based transfer printing of inorganic flexible electronics, the processes rely on interfacial competitive fracture. In multilayer flexible electronics, more layers bring more interfaces. As different layers have different materials, structures, and fabrication methods, the interfacial properties differ greatly in terms of adhesion forces. When using the conventional stamp transfer or tear-off method, random interfacial delamination may occur on all layers instead of the desired bottom layer-substrate interface. This problem is avoided by using the LTP method. In Figure 4, we demonstrate the transfer process by direct peeling-off with a tweezer and the LTP method for a multilayer flexible device. The peeling-off process represents the stamp transfer process by applying external forces. The device had two layers. Figure 4a shows the schematics of the device structure. The top layer was a temperature sensor and the bottom layer was a strain sensor. During the peeling-off process, we used a tweezer to peel the device from one edge. The top and bottom PI layers were delaminated and part of the device in the bottom layer was destroyed, as shown in Figure 4b and Figure S5, Supporting Information. Next, for comparison, we used LTP to transfer the device. We found that delamination occurred only at the desired bottom layer-silicon wafer interface. Thus, the multilayer device was successfully fabricated, as shown in Figure 4c. We have also tested the performance of the double layer device before and after transfer. For temperature sensor, the result shows that the change of sensitivity coefficient before and after transfer is less than 1%, as is shown in Figure S7, Supporting Information. For strain sensor, sensitivity coefficient cannot be measured before transfer because of the friability of silicon substrate. Due to the limitation of silicon substrate, the film cannot be stretched at this time. Here we present the sensitivity after transfer and the initial resistance change before and after the LTP process. The result in Table S4, Supporting Information, shows that the resistance change is less than 0.7%. It is proved that there is no much change in the performance of double-layer device before and after transfer.

2.5. Mechanical Visualization of the Device Releasing Process

To quantitatively compare the device stress conditions during stamp transfer printing and LTP, we fabricated 4 × 4 strain sensor arrays and transferred them using the two methods. The sensor array signals were simultaneously recorded in real-time by a multi-channel resistance meter. The resistance change
of the array showed the in-plane distribution and evolution of the strain field during the two transfer processes (Equation 1), which can be used as a direct indicator of the device stress status. The mechanical properties of the transfer process were visualized using this method.

$$\frac{\Delta R}{R} = K_e$$

(1)

Figure 5a shows the peeling transfer of the array. In all the steps of the peeling test, there was considerable tensile stress on the surface (Figure 5b). Figure 5d shows the LTP transfer process on the same sensor array. The plane strain distribution mappings during the LTP procedure are shown in Figure 5e. When transferring starts, there is no plane strain on the film surface, as shown in Figure S8, Supporting Information. However, as the film starts to detach, there is some stress on the surface. Midway through the transfer, the film with the peeling test is under tension stress and the film transferred by the LTP method bears a small compressive stress. In the 50% transfer stage shown in Figure 5b, it can be seen from the cloud images that the whole-field stress of LTP is more uniform than in the peeling test. Extreme stress conditions begin to occur on the array pixels R2C4 (second row, fourth column) and R3C4 (third row, fourth column). When the transfer is almost complete, the entire film is pulled up by the buoyancy of the liquid, so that the attached angle point suffers a tensile stress. In contrast, when the sensor is totally separated from the substrate, it soon comes into a lower tensile stress condition because of liquid tension. As shown in Figure 5b,e, the entire sensor is connected to the resistance meter through the connected line, and there is a stress concentration at the connection during transfer; consequently, pixels R2C4 and R3C4 are prone to extreme stress values. To compare the LTP and peeling tests more intuitively, the time of the transfer process in Figure 5c,f were normalized; in these figures, the top x-axis is the time of the liquid transfer process and the bottom x-axis is the peeling test time. In Figure 5c,f, the real-time changes in the positions of pixel R2C4 and pixel R3C4 during the transfer process are shown. Figure 5c depicts the strain condition curve of the array

![Figure 4. a) Structure, b) peeling test, and c) LTP of the double-layered device.](image)

![Figure 5. a) Peeling test model of an array. b) Peeling test of a 4 x 4 strain sensor array and the direct measurement of transfer print strain distribution. c) Strain condition curve of pixel R2C4 (second row, fourth column) from the array during the entire peeling and liquid transfer print process. d) Liquid transfer model of an array. e) LTP of a 4 x 4 strain sensor array and the direct measurement of transfer print strain distribution. f) Strain condition curve of pixel R3C4 (third row, fourth column) from the array during the entire peeling and liquid transfer print process.](image)
pixel R2C4 during the entire peeling and LTP process. It is evident that pixel R2C4 is an area where stress is concentrated during the peeling test with a 2.1% relative change in resistance while the absolute value of stress for the LTP process is only 0.91%. Figure 5f shows the strain condition curve of the array pixel R3C4 during the entire peeling and LTP process. It can be seen that the average stress level of pixel R3C4 in the peeling test is more than four times that in LTP. The results show that the stress non-uniformity of stamp transfer and the maximum stress of the stamp transfer printing is three times that of LTP. Flexible devices bear greater stress during the process and are much easier to crack and fail, especially for semi-conductive and metallic materials with small elongation at break. These tests demonstrate the softness and gentleness of LTP. Moreover, this mechanical visualization design also provides a direct measurement and characterization method for evaluating new transfer printing methods.

3. Conclusion

In this study, we have presented a highly efficient and high yield ratio transfer printing method, i.e., the LTP method. It is based on the principle of hydrolysis of the chemical bond between the PMMA film and silicon wafer through liquid films. The device also self-flattens owing to the surface tension of the liquid film. The transfer printing tests of devices with different sizes, patterns, numbers, and multilayer structures give a nearly 100% yield ratio using LTP. In addition, the properties of the devices remained unchanged before and after LTP. By conducting a quantitative strain field in situ measurement, we demonstrated that the stress within the flexible device is minimal during the release process as compared to the stamp transfer printing-like process. Thus, using LTP, large-scale, intricately-structured, and multilayer devices can be transfer-printed in a highly efficient and high quality manner.

4. Experimental Section

**Pretreatment of Silicon:** A Si wafer (3 inch, single side polishing) was soaked in the AZ400K developer (50 mL) for 5 min, followed by ultrasonic cleaning with acetone (50 mL) for 10 min to remove organic impurities from the wafer. The wafer was then thoroughly washed with ethanol (50 mL) to remove the acetone remaining on the surface. Finally, the wafer was baked at 110 °C for 10 min to completely evaporate ethanol.

**Design of the Masks:** To assess the success rate of the method, square patterns were designed with different aspect ratios, hollow patterns, solid patterns, and patterns with sharp points, which might be difficult to transfer using the traditional transfer method. A strain sensor array and double-layered sensor were also designed to demonstrate the advantages of the LTP method. The patterns were made into masks, which were used in the photolithography step.

**Preparation of the PI Substrate:** After PMMA (5 mL) reached room temperature, it was spin-coated at a speed of 800 rpm for 6 s for distribution on the entire surface of the prepared silicon wafer. The polymer was then spin-coated at a speed of 3000 rpm for 30 s to control its thickness. Next, the silicon wafer was baked at 180 °C for 20 min to cure the PMMA layer. The PI was distributed by spin coating (5 mL) at 600 rpm for 6 s on the cured PMMA layer, and its thickness was controlled by spin coating at 3000 rpm for 30 s, followed by a final baking process of an hour each at 80, 120, and 180 °C. After the curing process of PI was complete, PI was closely bonded to the silicon wafer.

**Pattern Fabrication:** Different layers of metal (10 nm Cr + 150 nm Au, for instance) were deposited on the PI surface by an electron beam. Using the designed mask, after metal evaporation, photolithography, chemical deposition, and wet-etching steps, different patterns were made on the PI film. Further, after a series of MEMS processes, different functional sensors were fabricated as well.

**Method of Traditional Stamp Transfer:** Traditional transfer methods use stamps to transfer the microstructure from an existing substrate to a designated new substrate. The general steps of the traditional transfer process are as follows: First, a microstructure with certain functions is prepared on the donor substrate by a conventional micromachining process. Then, the surfaces of the stamp and microstructure are cleaned by the abovementioned surface treatment, and the stamp is attached to the microstructure. Because the adhesion between the stamp and the microstructure is related to speed, to ensure that the microstructure can be torn together with the stamp, picking must be performed at a sufficient speed. The surface with the microstructure under the flexible stamp is closely attached to the surface of the acceptor base body, and after applying pressure for a period of time, the surface of the microstructure and that of the acceptor base body forms bonds. Acknowledging the effect of speed on the bonding of the interface, the flexible stamp was torn at a slow speed to ensure that the microstructure remained on the receiver substrate.

**Method of Liquid Transfer:** In the first step of the LTP process, silicon was pretreated and the PI substrate was prepared for fabrication of the patterns. Next, the prepared silicon-based device was placed in the AZ400K developer to achieve the transfer process (strong alkali, KOH, 50 mL), and after several hours (time depends on the transfer size), the PMMA-PI-sensor microstructure was detached from the Si substrate. Several minutes after the microstructure was completely detached, it was pushed up by the buoyancy of the liquid and the surface tension of the liquid-air interface made the film stretch on the surface. Therefore, a temporary PDMS plank substrate was used for its surface hydrophobicity. The PDMS plank approached the liquid surface and device from the bottom. The plank was then raised slowly to hold the device and remove it from the liquid. After its extraction from the liquid, the cleaning procedure was followed. Subsequently, the microstructure was released in water to obtain the inorganic electronic device under the PI flexible substrate. Finally, the plank process was repeated to passively print the device on the flexible substrate.

Supporting Information

Supporting Information is available from the Wiley Online Library or from the author.

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.
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