# A laser-driven programmable non-contact transfer printing technique

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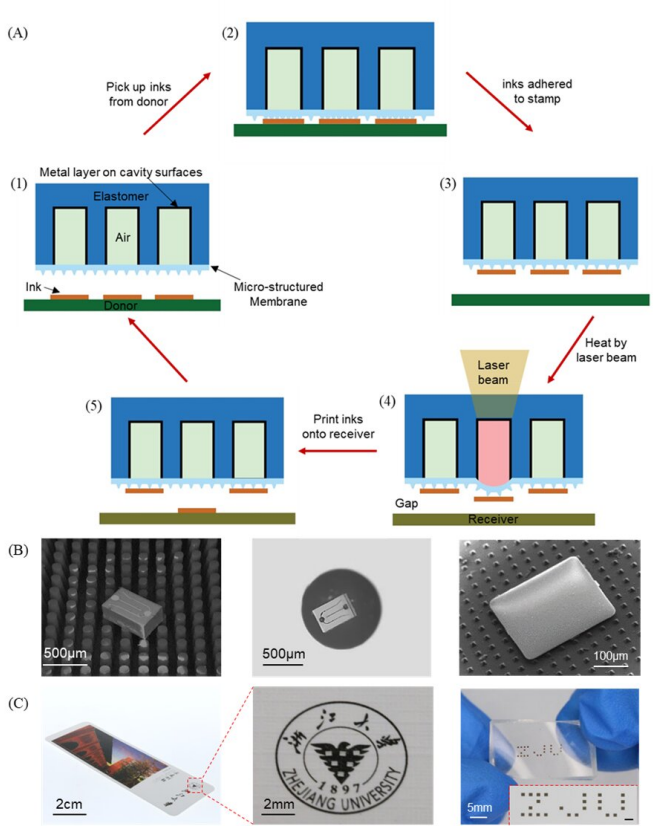


(A) Schematic illustration of the laser-driven programmable non-contact transfer printing process via an active elastomeric micro-structured stamp. (B) Printing single Si platelet and LED chip onto various receivers. (C) Programmable printing Si platelets and LED chips onto various receivers. Credit: ©Science China Press

A laser-driven programmable non-contact transfer printing technique via an active elastomeric micro-structured stamp, which offers continuously thermal-controlled tunable adhesion with a large switchability of more than 103 at a temperature increase below 100 °C, is developed. This innovative technique creates engineering opportunities in a wide range of applications such as flexible electronics, paper-based electronics, bio-integrated electronics, and microLED displays, where the heterogeneous integration of diverse materials is required.

Transfer printing is an emerging assembly technique to transfer micro/nano-objects (i.e., inks) from one substrate (i.e., donor) to another substrate (i.e., receiver) using soft polymeric stamps. The transfer printing technique enables the assembly of diverse materials in various structural layouts with large throughputs of thousands of objects per second, and is valuable in developing advanced electronic systems such as flexible and stretchable inorganic electronics requiring the heterogeneous integration of inorganic materials with soft elastomers, which represents one of the ongoing technology revolutions in the electronics industry.

Various approaches based on tunable dry adhesives have been utilized to develop transfer printing techniques, including contact techniques and non-contact techniques. The performance of contact techniques critically depends on the receiver's geometry and properties since the printing requires the contact of the stamp to the receiver. In contrast to contact transfer printing techniques, non-contact approaches eliminate the influence of the receiver on the transfer yield and allow non-contact printing of inks onto arbitrary receivers. However, existing non-contact transfer printing techniques usually induce undesired high temperature increases in the system, which may cause permanent interfacial damages and limit their broad utilities in transfer printing of brittle materials, for example, silicon, which is widely involved in conventional electronics.

In response to this challenge, Song's group in Zhejiang University developed a laser-driven programmable non-contact transfer printing technique via a simple yet robust innovative design of an active elastomeric micro-structured stamp with tunable adhesion. The tunable adhesive

features cavities filled with air and encapsulated by a micro-patterned surface membrane duplicated from low-cost and easily available sandpapers. The micro-patterned surface membrane can be inflated dynamically to control the interfacial adhesion by heating the air in cavities through a metal layer (e.g., iron particles) on the inner cavity surface, which serves as the laser absorbing layer. This construct offers continuously thermal-controlled tunable adhesion with a large switchability of more than three orders of magnitude at a temperature increase below 100 °C.

This active adhesive extends concepts developed for contact printing techniques and enables the development of a novel laser-driven programmable non-contact transfer printing technique. Theoretical and experimental studies reveal the fundamental aspects of the design and fabrication of the active elastomeric micro-structured stamp, and the operation of non-contact transfer printing. Demonstrations in programmable transfer printing of micro-scale Si platelets and micro-scale LED chips onto various challenging flat or rough receivers (e.g., paper, steel sphere, leaf) with ultra-low adhesion illustrate the unusual capabilities for deterministic assembly that have been difficult to address by existing printing schemes. This innovative laser-driven non-contact transfer printing technique creates engineering opportunities in a wide range of applications such as flexible electronics, paper-based electronics, bio-integrated electronics, and MicroLED display, where the heterogeneous integration of diverse materials is required.

**More information:** Hongyu Luo et al, Laser-Driven Programmable Non-Contact Transfer Printing of Objects onto Arbitrary Receivers via an Active Elastomeric Micro-Structured Stamp, *National Science Review* (2019). DOI: 10.1093/nsr/nwz109