Highly sensitive adhesion

A synthetic, reversible adhesion system based on a gecko foot delivers impressive results, in particular for **MICROHANDLING**. Inspired by nature, the physical principle utilised leaves sensitive surfaces intact, conserves resources and can be used with no size restrictions.

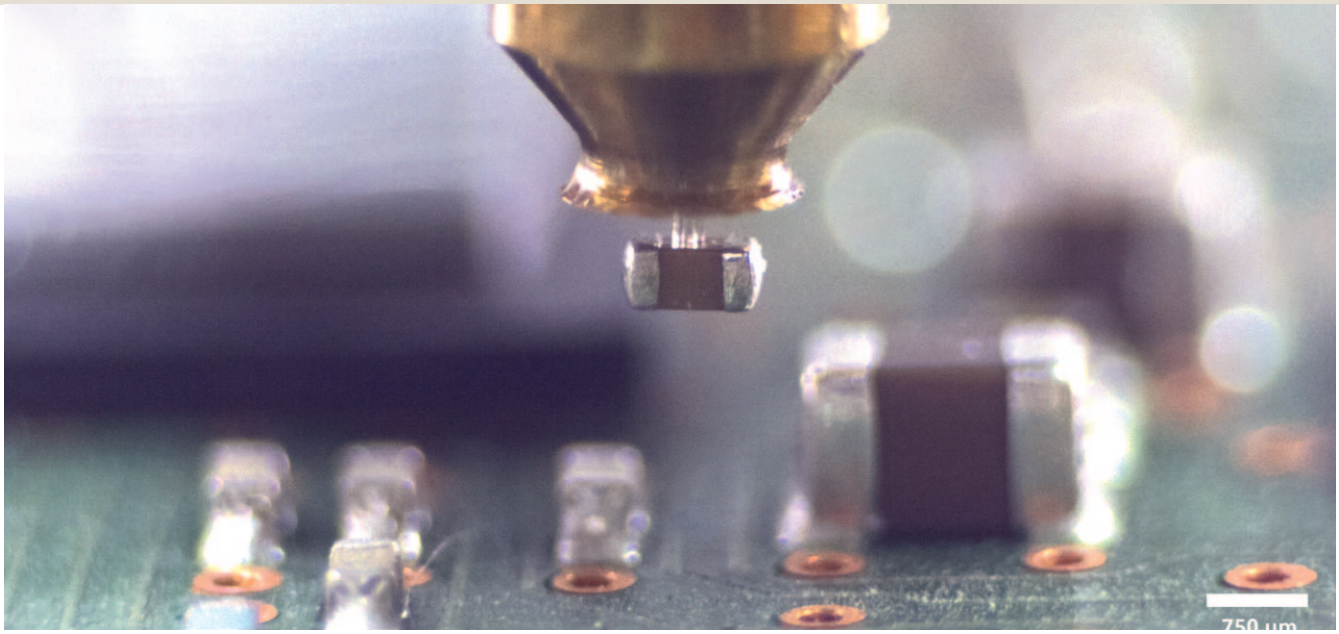

Figure 1. Assembly of a circuit board with electronic components, with micrometre accuracy care of the ›Gecomer‹ technology

MARC SCHÖNEICH, HENRIK OLLMANN AND FABIAN RUNDEL

Our industrial society is shifting from standardised products towards increasingly individual products tailored to customer needs. The increasing levels of automation and miniaturisation that contribute to companies' profitability these days are in contrast to the growing demands for product flexibility and individuality. Appropriate handling approaches play a central role in these developments.

Miniaturisation of functional mechanical, optical and electronic assemblies creates space for a flexible product design. Handling technology has to be able to keep up with this trend. To survive in the market in the future, automation of high-volume production lines will have to be combined with the variability of individual production based on innovative handling concepts to achieve what has been called ›mass customisation‹ – in other words a kind of customised high-volume production.

This is precisely the focus of ›Gecomer‹ technology, developed by Saarbrücken-based company Innocise. A spin-off from the INM – Leibniz Institute for New Materials, an internationally respected research institution in the field of materials research, the deep tech start-up is developing pioneering handling systems for industrial pick-&-place processes. The technology is based on microstructures inspired by nature, which use intermolecular forces, also known as Van Der Waal's interactions, to achieve reversible adhesion on a wide variety of surfaces and materials **(Figure 1)**. As the gripping solution is not dependent on any external energy supply, it enables energy-efficient, sustainable handling, making it the key to the highly versatile and smart production lines of the future.

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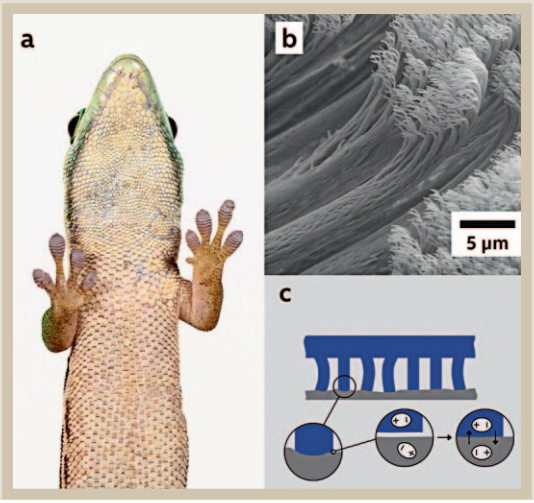

Figure 2. Microstructured adhesion systems in nature and their application to synthetic handling solutions: a) lamella-like macroscopic structure of a gecko's foot; b) scanning electron microscope image of the finely branched fibrillary adhesion organs on a gecko's foot; c) schematic view of an adaptive synthetic adhesion structure and its adhesion principle based on Van Der Waal's interactions

Applying the gecko effect to technology

But how can an adhesion force be generated without external mechanisms such as electrical or magnetic fields, a vacuum or adhesives that leave a residue? Innocise utilises an effect found in nature, and based on what is known as the gecko effect. The adaptive, microscopic (fibrillary) adhesive organs on a gecko's foot provide temporary and reversible adhesion on a wide range of surfaces **(Figure 2)**. Based on this example from nature, an artificial reversible adhesion system has been developed. Because the adhesion is dry, residue-free and purely physical, it can be utilised in applications across a number of industries.

The basic principle of microscopic dry adhesion systems is based on the observation that microstructured surfaces typically have greater adhesion than unstructured, flat adhesives. This is known as the principle of contact splitting. Over a given area, the adhesive effect is greater the more smaller points the total area is divided into. At this micro and nano scale, surface effects known as Van Der Waal's interactions are the dominant forces. These weak intermolecular interactions occur temporarily at an atomic scale between two polarisable molecules without changing the material properties of either of the surfaces involved. The overall adhesive effect can be scaled up continuously and almost without limit by multiplying the number of points.

The Gecomer technology is already being used in numerous areas such as the pharmaceutical industry, battery and fuel cell production and the optical and packaging industries, where it works reliably for well over a million pick-&-place cycles.

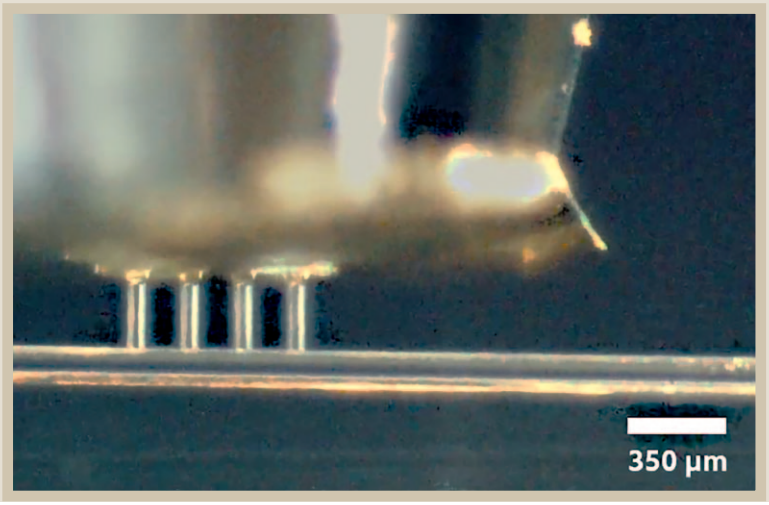

Figure 3. Gripping a 200 µm diametre glass fibre using a tailored gripper inspired by nature

After successfully entering the market in the field of macroscopic gripping systems, Innocise has further developed its gripping solution to handle component sizes of just a few micrometres. This ›microhandling‹ is aimed at totally new markets and customers. Microhandling technology closes an important gap in existing handling tasks for miniaturised objects. Example applications cover everything from gripping photonic components such as microlenses or glass fibres to tiny sensor and electronic components (SMT assemblies) through to production of state-of-the-art LED displays.

Microhandling in photonics

The demand for high-speed broadband communication is constantly increasing. For example, according to

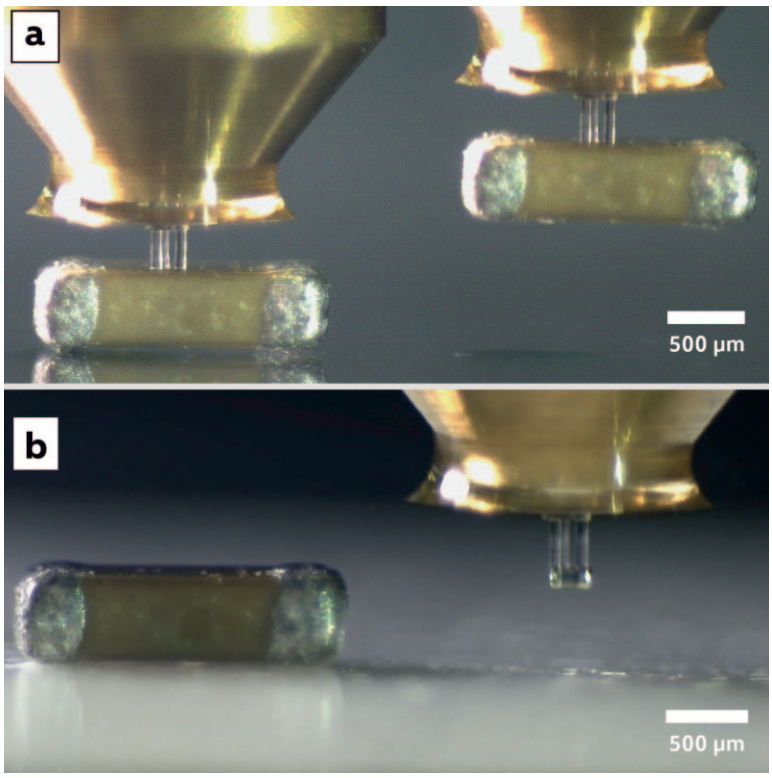

Figure 4. Pick-&-place for micro-electronic components using Gecomer technology: a) pick and place cycle for a 2012M SMD; b) placing an 0201M SMD next to a 2012M SMD using the same gripper

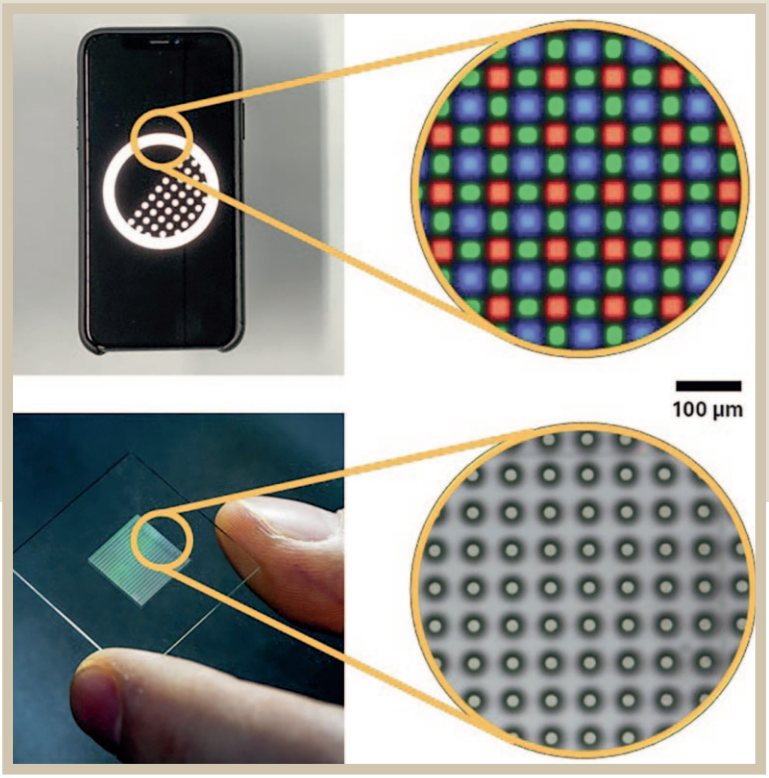

Figure 5. Top: Red, green and blue 20 µm LEDs for a smartphone display; bottom: tailor made gripper for simultaneous mass transfer of several thousand LEDs

the Telekom annual company report, data traffic over fixed networks increased by 30 percent worldwide in 2019. The coronavirus pandemic brought a further sharp rise, with home working and home schooling creating an increased long-term demand. This huge and growing density of information can only be handled by the latest generation of optical data networks and systems. They use polarisation maintaining optical fibres, which can transmit a large number of different signals simultaneously through a single fibre. Connecting these fibres is a particularly challenging task. The fibres have to be adjusted and installed not only laterally but also in terms of their rotation/polarisation, without changing any of their optical properties. Innocise supplies tailored handling solutions specifically designed for this application **(Figure 3)**. They provide excellent flexibility and durability, and their operating principle is inspired by nature. Adhesion is reversible and gentle but still provides a reliable bond with the fibre surface without causing any mechanical stresses that would change the polarisation of the fibres.

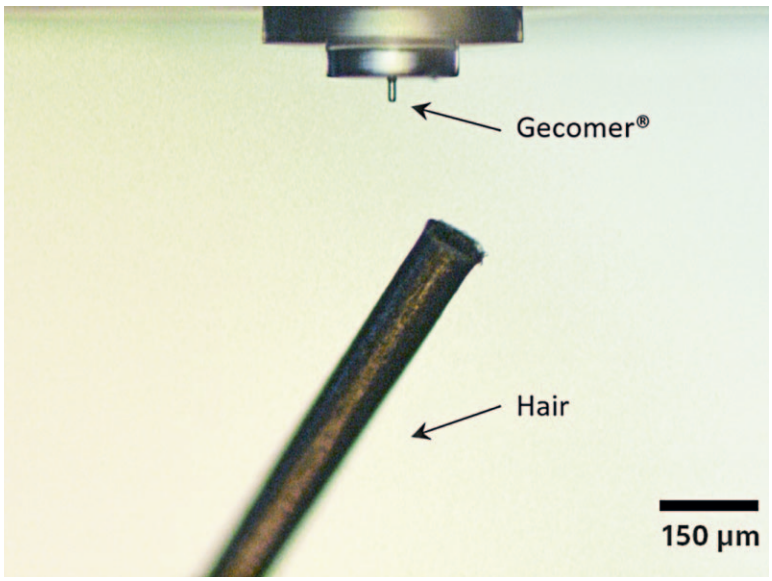

Figure 6. A 10 µm Gecomer adhesion structure with size comparison to a human hair (80 µm)

Flexibility in SMT assembly

Today's smartphones represent an increasing challenge when it comes to assembling the circuit boards installed in them. On the one hand, the increasingly small SMDs mean that the packing density is increased, while on the other hand an increasing number of sensors and other components of different designs have to be integrated. The latest SMT sensors, for example for determining air pressure, use filigree membranes as the measuring element. Similar to the equally sized microphones, they thus present a major challenge for conventional handling systems. Vacuum grippers can damage the membranes, while parallel grippers are often too specialised and cannot achieve a sufficiently high volume per unit of time. This results in frequent tool changes or assembly machines specialising in just a few components. A sensitive gripping system that can pick up and precisely place SMDs of different sizes and sensitive sensors without the need for tool changes or specialised systems would be of huge commercial interest. The technology outlined makes this possible. For example, it enables standard 0201M (250 × 125 µm²) to 2012M (2.0 × 1.25 mm²) SMDs to be reliably handled using a single tool **(Figure 4)**. The principle behind this gripping technology based on Van Der Waal's interactions can also minimise energy costs and the environmental footprint of production facilities, as they are not reliant on compressed air or any other energy sources.

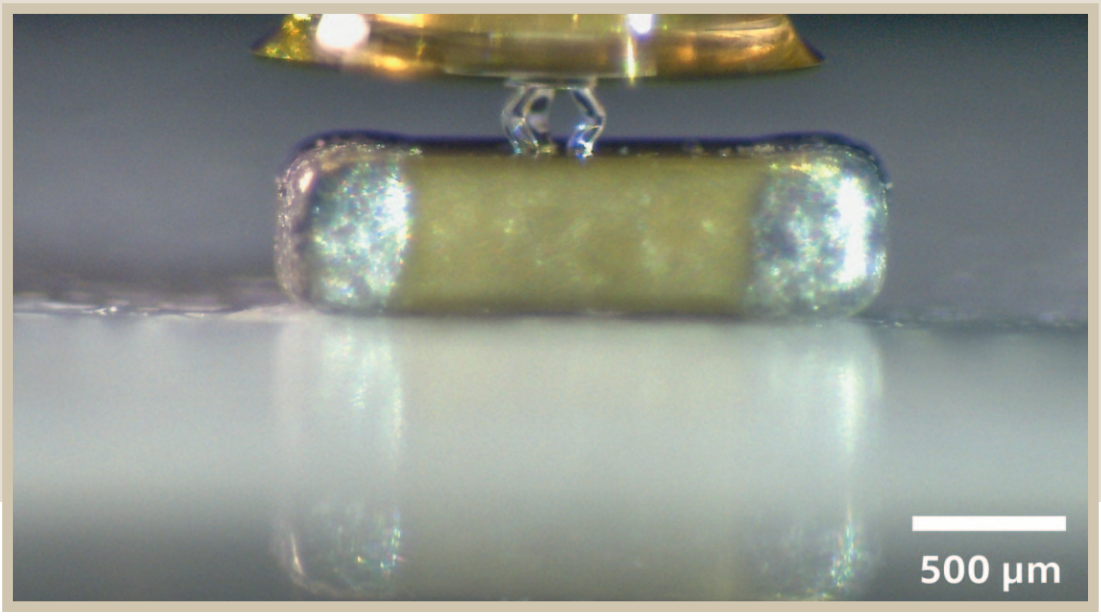

Figure 7. Patented release mechanism for defined placement of microscopic components by buckling of the pillar structure

Mass transfer of micro-LEDs

Staying in the realm of smart devices for wireless communication, there is another possible use in terms of reducing costs and material usage, namely in micro-LEDs. Widespread use of this technology is currently limited by its handling. At sizes of less than 10 µm per light element, only disruptive handling technologies are in the frame. If we also look at the huge quantity of elements to be transferred – over 100 million for an 8K screen – it is apparent that an individual gripper is not suitable for this Sisyphean task. The solution is a gripping system capable of transferring thousands of light elements precisely and with no residue with a maximum yield and in a single cycle **(Figure 5)**. The technology really demonstrates its adaptability here as the use of elastic materials enables it to pick up slight misalignments. This vertical flexibility allows faster alignment and significantly reduces the cycle times.

Innocise develops these gripping and transfer systems to customer specifications and to meet specific requirements in production. With object sizes of a fraction of the width of a human hair, high-resolution cameras are required for localisation **(Figure 6)**. A major advantage of the gripping systems described is that their transparency enables camera systems to be integrated directly into the tool, greatly simplifying alignment of the gripper with the object matrix. It makes no difference whether a simple rectangular field is to be transferred or one with any other geometry, for example the shape of a company logo.

Adaptive design

The use of high-resolution laser lithography to produce structures enables Innocise to offer gripping solutions for a huge variety of different objects. The flexible design, coupled with the expertise to apply these adhesive structures to different holders in a targeted way, opens up totally new opportunities in assembly.

Similar to the gecko's microscopic adhesion organs, the grippers are made up of pillar-like microstructures. The size, number and arrangement of these columns can be modified and thus adapted precisely to an object to be handled. Despite the miniaturised design, standardised adhesive forces of over 2 kg/cm² can be obtained, thus ensuring reliable handling. The patented release mechanism enables purely mechanical switching between a strong adhesive and a weak adhesive state, which means that objects can be set down accurately in the designated position after the transfer cycle **(Figure 7)**.

Nonetheless, despite the technological advantages offered, many companies do not switch to a different handling technology. This is because of the high costs involved in planning and acquisition of the production plants. To protect investments, the adhesion systems can therefore be tailored not only to the object to be gripped but also to the existing production facilities. Here, plant manufacturers and operators alike benefit from a lean gripper portfolio, which can cover a broad range of object sizes.

In collaboration with partner companies, Innocise is continuously working on new innovations to constantly improve the technology and open up more applications. To enable the supply of innovative and smart gripping systems for green production in the future, Innocise is cooperating intensively with businesses from a wide range of sectors. ■

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