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Fraunhofer Institute for Laser Technology ILT

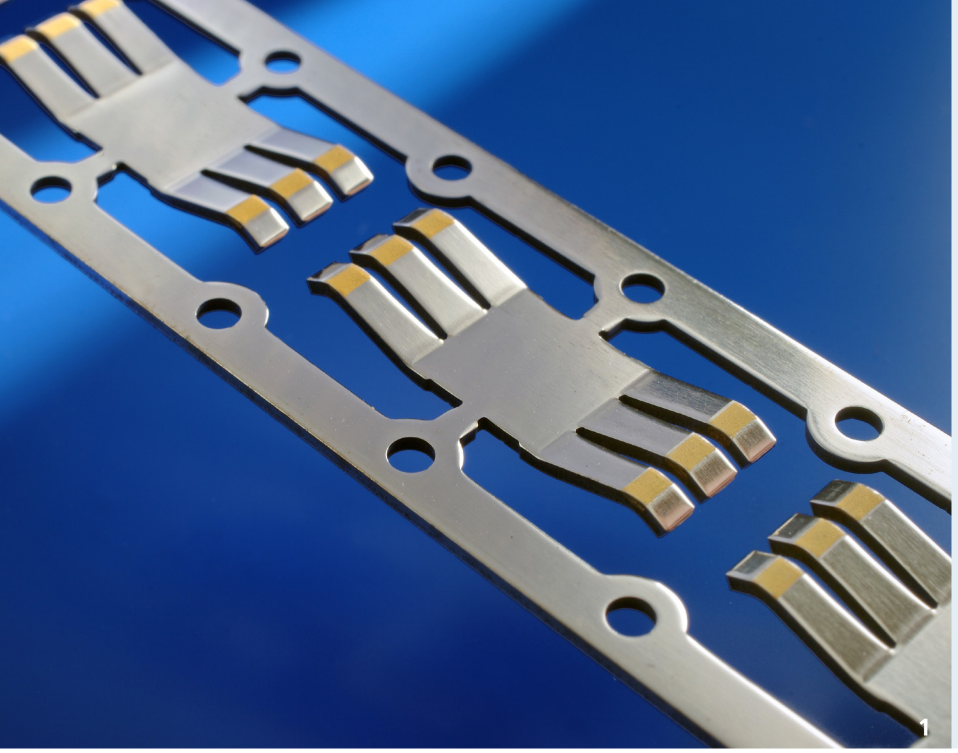
Printed Electronics

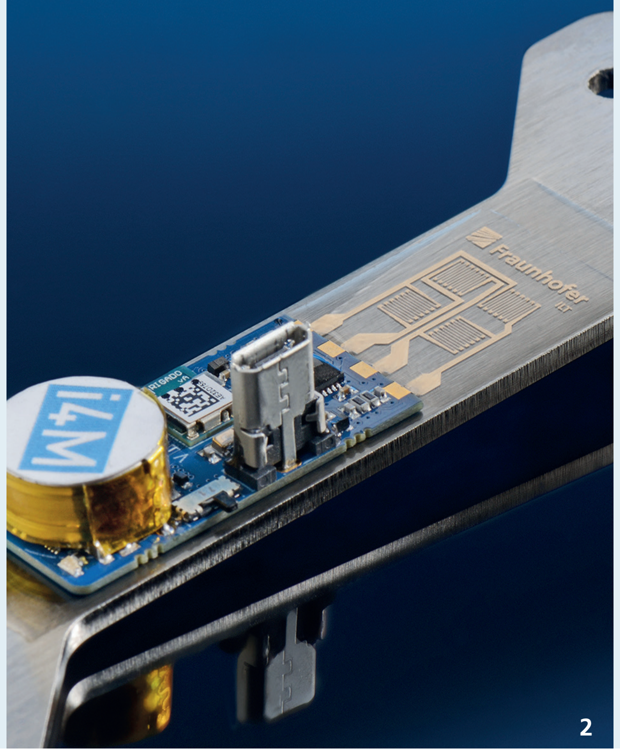
Printed electronics are opening up more and more fields of application in our everyday lives, for example in OLED displays, solar cells or e-book readers. But which manufacturing processes and materials will determine the applications of the future? The Fraunhofer Institute for Laser Technology ILT develops digital, energy-efficient and resource-saving solutions for such future challenges.

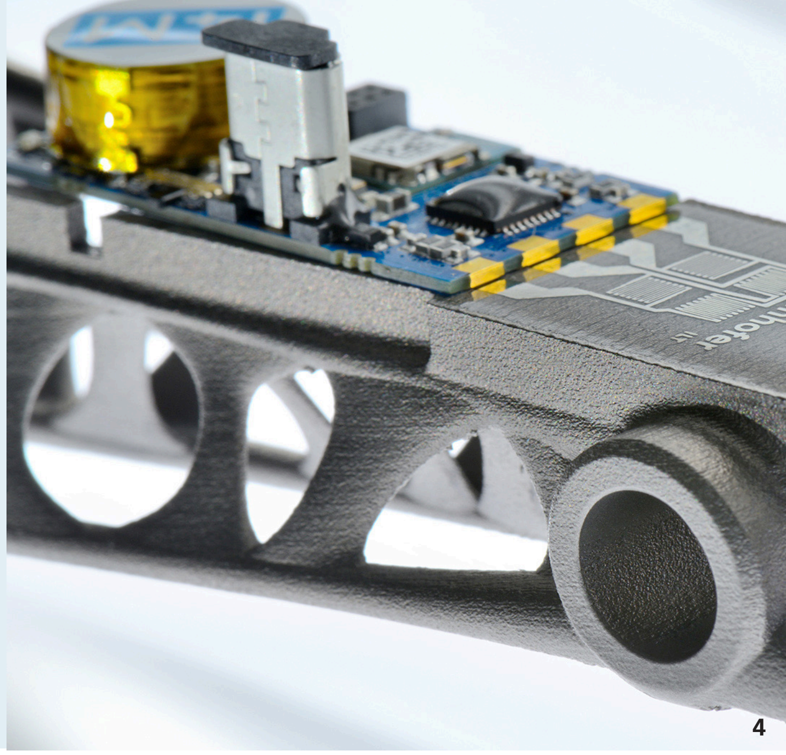
Printed gold: expensive raw materials used wisely

Today, gold plating for high-quality contact points is produced using electroplating or chemical and physical deposition processes with PVD and CVD. These processes are cost and time intensive and sometimes use environmentally harmful and toxic chemicals. By combining printing and laser processes, the industry can reduce its consumption of cost-intensive precious metals and stop using environmentally harmful chemicals in electroplating processes altogether. Thanks to newly developed laser processes, selectively printed gold pastes can be produced on Ni-Cu substrates.

Piezoelectric micro actuator.







Laser process for the functionalization of pressed electronics

Up to 80 percent of the gold previously used can be saved in this way. The gold layers metallurgically bonded to the substrate material have layer thicknesses of 2 to 5 µm and are mechanically very robust.

Electrical conductors on and in fiber composite plastics

Fiber-reinforced plastics (FRP) have become indispensable in lightweight construction. New manufacturing processes are required, however, as the demand for FRP grows and mechanically monitored, complex structural components or heated components are being functionally integrated into electric aircraft. When digital printing and laser processes are combined, electrical functions (heating, measuring strain, measuring aging, signal lines, etc.) can be integrated on and in FRP. Compared with oven post-treatment processes, this combination process produces layers that put lower thermal stress on the component and that have variable electrical properties.

Piezoelectric actuator coatings

Microelectromechanical systems (MEMS) are turning our smartphones into helpful everyday tools full of useful and compactly integrated functions. Microactuators, such as those in microspeakers or micropumps, are driven by thin piezoelectric functional ceramics that mechanically deform when an electric field is applied. When conventional manufacturing processes are used for microelectronics, producing such piezoelectric multilayer systems is extremely time-consuming and costly. The time and cost required to manufacture highly functional thin-film MEMS on an industrial scale can be reduced significantly, however, by combining inkjet printing with laser-based functionalization processes.

Printing sensors directly onto components

Today, foil strain gages are usually applied to components by hand, a process that requires many steps, experience, time and intuition. Thus, the installation of the strain gauge is usually the largest cost component for using these sensors. Additive manufacturing not only makes it possible to print strain gauges on inexpensive carrier films, strain gauges can also be printed directly onto a component, eliminating the manual step of gluing them on. Coating processes such as dispensing or inkjet printing can apply the necessary functional layers from a digital model in an automated and precise manner. A laser performs the necessary post-treatment in a few seconds without the need to heat the component in an oven. By using a WLAN-capable evaluation board, users can monitor the components wirelessly. In addition to strain gages, temperature sensors, conductive tracks or heating structures can also be applied to the components.

"Sensing" components from the printer

When laser-based metallic 3D printing (laser powder bed fusion LPBF) is combined with inkjet printing or dispensing for the printing of sensors, sensing components can be manufactured fully additively. In this process, the sensors can be applied to the finished printed components or inserted into the component during the LPBF process. For this purpose, the process is paused at the appropriate time, the insulation layer is printed onto the defined areas and laser-cured. Printing and thermal post-treatment are performed equivalently for the measuring grid and encapsulation.

The LPBF process is then continued without damaging the printed structures. This procedure opens up completely new possibilities for the design of »smart« components, since the purely digital process chain enables individual component and sensor designs to be produced down to batch size 1. This way, components can be made for use in Industry 4.0, such as the »Internet of Things« and the "digital twin". As an example, strain sensors could be integrated in a milling head manufactured using LPBF.

1 Selectively gold-plated contact points.
2 Piezoelectric microactuator.
3 Printed wireless strain gauge on steel component.
4 Printed strain gage on 3D printed milling head.

The advantages at a glance

- High degree of automation due to additive approach
- Precise adjustment of resistance values by laser processing
- Possibility of processing new materials and material combinations through targeted energy input
- Reduction of material requirements through suitable coating processes
- Laser process for the functionalization of printed electronics

Fraunhofer Institute for Laser Technology ILT

The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer Gesellschaft.

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