Sensor packages for autonomous cars enabled by additive manufacturing

The EU-funded Horizon 2020 PROJECT TINKER is developing a new reliable, accurate, functional, cost- and resource-efficient pathway for RADAR and LiDAR sensor package fabrication

Sensor Packages for Autonomous Vehicles and Advanced Driver-Assistance Systems
Source: Robert Bosch GmbH

Autonomous driving and self-driving cars are important use cases for microelectronics and sensors – most importantly, radio detection and ranging (RADAR) and light detection and ranging (LiDAR) sensors. The market potential for those sensors is enormous, with automotive and industrial applications of LiDAR expecting to experience a 26% compound annual growth rate (CAGR) in the 2020-2026 period. Specifically, the market segment of advanced driver-assistance systems (ADAS) anticipates an even more impressive growth of 111% [1]. The fast market growth is fuelled by factors such as increased share of AD vehicles; or the growing need for sensor complexity for higher automation levels [2].

Public awareness and the industrial need for further miniaturisation of RADAR and LiDAR sensor packages are the main drivers of ongoing efforts in the automotive sector to integrate these sensors into the body of a vehicle, such as in the bumpers, grilles, and exterior lamps. Therefore, high-value and high-performance systems are necessary for ADAS as well as for completely autonomous cars. Currently their relatively large size, weight, and power consumption represent major bottlenecks, particularly in the automotive sector. Therefore, further miniaturisation, improved functionality and efficient use of resources are in high demand.

TINKER pilot line

For a period of three years, the EU-funded TINKER project is therefore developing a new reliable, accurate, functional, cost- and resource-efficient pathway for RADAR and LiDAR sensor package fabrication.

The TINKER project set out two main objectives: establishing a pilot platform based on additive manufacturing techniques; and showing the platform's potential by fabricating the sensor packages themselves. TINKER's approach is to employ key enabling technologies, especially inkjet printing and nanoimprint lithography (NIL), as disruptive and flexible manufacturing techniques in micro-part assembling.

The proposed TINKER pilot line will offer a high degree of flexibility and reliability due to its modular character. In addition, advanced inline feedback control mechanisms will be directly integrated into the line.

Consortium of ten companies

The TINKER consortium consists of ten companies, who are all major players in the field of semiconductor and microelectronic manufacturing, as well as in the fields of material and process development. All partners also have an impressive track record of nationally- and internationally funded projects.

Consortium Partners

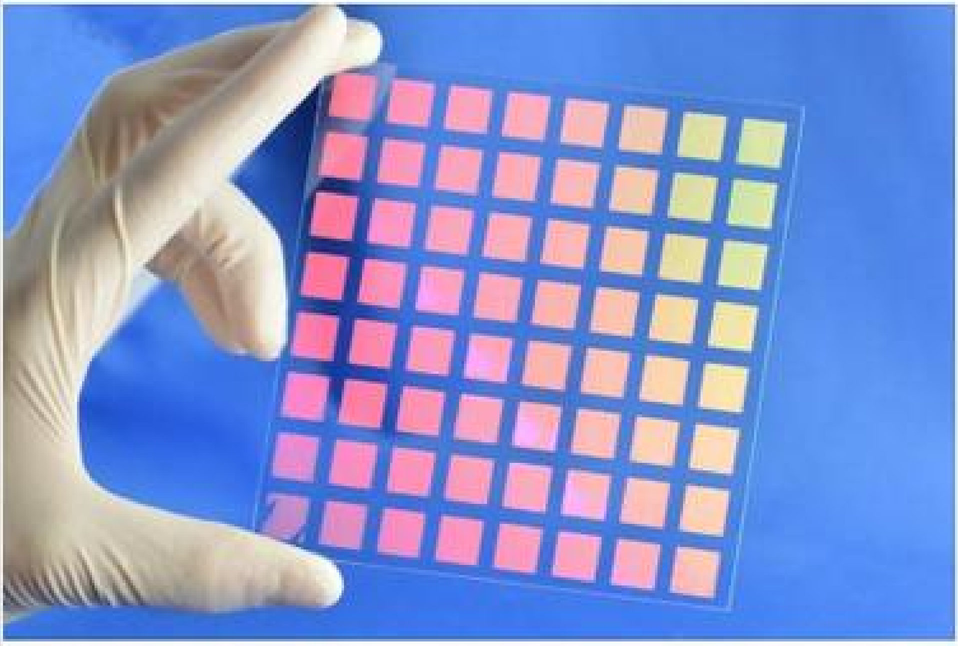
1. Profactor GmbH
2. Amires s.r.o.
3. Robert Bosch GmbH
4. Automotive Lighting Italia Spa
5. Besi Austria GmbH
6. Commissariat A L'Energie Atomique Et Aux Energies Alternatives
7. Notion Systems GmbH
8. Infineon Technologies AG
9. EV Group E. Thallner GmbH
10. Sentech Instruments GmbH
11. Idryma Technologias Kai Erevnas Frt – Foundation for Research and Technology - Hellas
12. P.V. Nano Cell Ltd.
13. TIGER Coatings GmbH & Co.
14. Inkron Oy
15. Austrian Standards International

Cooperating across Europe for over a year now, the partners are well aware of what advantages the project can bring to them, as well as to the industry. For instance, Bosch GmbH see this project as an excellent opportunity to adapt inkjet materials to automotive requirements, as inkjet-printed waveguide antennas provide additional degrees of freedom for testing antenna geometries, which leads to optimised performance, cost savings and generates significant competitive advantages.

For Notion Systems, who are designing and building the TINKER platform, the project is an excellent opportunity to bring inkjet-, laser- and inspection technologies into one compact system. The technologies will benefit from each other and allow for the fabrication of parts with a new degree of freedom and quality.

FORTH R&D team is focusing on designing and investigating advanced laser techniques for novel fabrication processes, which has significant industrial potential. Within the TINKER framework, FORTH has designed the new laser sintering module for industrial purposes and is anticipating optimising it for implementation into the Inkjet printer system. The laser sintering module will ensure local optical energy distribution over the ink patterns avoiding damage of heat sensitive substrates at speeds up to 7000mm/sec.

Further, the coordinating partner PROFACTOR GmbH is developing novel processes for additive manufacturing, contributing to several aspects of the project. In addition, PROFACTOR is central to the development of feedback control mechanisms and interoperability of pilot



Innovative Manufacturing Techniques
Source: PROFACTOR GmbH

line parts in close cooperation with involved partners. As digitalisation and automatisation progresses, these aspects are key elements of the TINKER project and provide a significant competitive advantage.

Project results

Within the first year, the partners have made noteworthy progress in establishing the TINKER pilot line and the innovative techniques it aims to employ. Their public results are downloadable on the project website in the form of individual reports for a high-level overview of the project results.

As the TINKER consortium is developing a NIL-based fabrication method for photonic integrated circuits of LiDAR sensors, one of the reports introduces the NIL infrastructure and tools available, as well as those developed specifically for the TINKER project. The photonic integrated circuit is the very precise core element necessary for the manipulation of light for each LiDAR sensor. TINKER aims to replace certain fabrication steps in an optical phased array (OPA) process flow with NIL to achieve fast and reliable direct manufacturing of the needed passive optical elements, such as the waveguides and optical coupling structures. This will reduce the size of the photonic IC device and its fabrication costs, as well as increase the throughput of its production. An important goal is also the integration of inline process monitoring for different production processes: pick and place, inkjet printing, and NIL. These processes pose multiple requirements on inspection and inline monitoring. Sensor technology deployed in TINKER to meet these requirements comprise optical inspection, curing sensor, and thermographic imaging.

In January 2022, two more public reports were released, focusing more on the material side of the project. One of them demonstrates a prototype of NIL resist with high reflective index, which is both ink-jet compatible and nano-imprintable. It is previewed to act as a functional material in the waveguides of the optical phase arrays of the LiDAR sensor demonstrators in TINKER. Inkjet printing of the high refractive index resist allows for digital deposition of the material specifically to locations where it is needed. Additionally, it allows for variation of the layer thickness to accommodate for the varying volume filling in the structures.

Finally, the second report introduces the newly developed inkjettable materials. On one hand, it presents the high metal content UV curable inks, which enable conductive patterns with appropriate physical structure and are compatible with rigid and flexible polymeric substrates. On the other hand, it describes UV-(LED) curable dielectric materials with low shrinkage properties and inks with high thermal conductivity, which will allow a sufficient heat transport.

Next steps

Partners are working on developing and perfecting designs, processes and materials required for the two selected use cases. They have collaborated successfully on developing equipment and tools and shared samples, technologies, and processes. Examples of such fruitful collaborations are the completion of the pick-and-place equipment prototype, creation of the initial setup for improved inline monitoring and feedback, and the infrastructure and tools set up for NIL. In January 2022, the material aspect of the project has also seen advances, with the high reflective NIL resist prototype being introduced. The consortium has had great achievements in development of prototypes of both equipment, tools and materials for the TINKER pilot line, and they managed to create a solid base for achieving the project's ambitious goals.

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Image sources: Robert Bosch GmbH/ PROFACTOR GmbH