Shrinking RADAR and LiDAR sensor packages – an introduction to TINKER

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Autonomous driving and self-driving cars are prominent use cases for microelectronics and sensors—most importantly, radio detection and ranging (RADAR) and light detection and ranging (LiDAR) sensors (**Figure 1**). The RADAR and LiDAR markets have enormous potential, with the market size of LiDAR sensors in automotive and industrial applications estimated to reach 26% compound annual growth rate (CAGR) in the 2020-2026 period. The market segment of advanced driver-assistance systems (ADAS) is expecting an even more impressive growth of 111% [1].

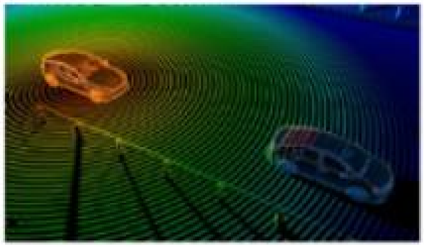

Figure 1: Autonomous cars are prominent use cases for RADAR and LiDAR sensors.

Public awareness and the industrial need for further miniaturization 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, instead of attaching them to the exterior of cars. Safety for both the driver and others is the most important consideration in the automotive sector. Therefore, high-value and high-performance RADAR and LiDAR systems are required for ADAS as well as for autonomous cars. Current bottlenecks are the relatively large size, weight and power consumption of such sensor devices. Because these factors are highly limited within cars, further miniaturization and improving functionality and efficient use of resources are highly demanded.

For a duration of three years beginning on October 1, 2020, the European Union's Horizon 2020 funded TINKER project [official project name is "Fabrication of Sensor Packages Enabled by Additive Manufacturing"] is set to develop a new reliable, accurate, functional, cost- and resource-efficient pathway for RADAR and LiDAR sensor package fabrication, following two main objectives. The first objective is to establish a platform based on additive manufacturing. The second objective is to fabricate RADAR and LiDAR sensor packages as use cases. TINKER's approach is to use 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. Additional key components are inline feedback control mechanisms, which will be directly integrated. **Figure 2** shows the basic concept and components of TINKER. Starting from bare dies for LiDAR and RADAR chips, pick-and-place processes and inline inspection for feedback control will be complemented by functional inkjet printing and nanoimprinting to fabricate sensor packages for the RADAR and LiDAR use cases.

The TINKER project aims to decrease production time, measurably increase automation level, achieve a higher or similar precision level as compared to the state of the art in manufacturing of these device types, and reduce rejection

Figure 2: The TINKER platform provides new additive manufacturing concepts in a pilot line for use cases such as RADAR and LiDAR sensors.

rates during the production process. The main purpose of this project is to widen the range of available miniaturization and microelectronic fabrication possibilities, including novel approaches in assembly processes added directly into production steps. TINKER will also train PhD and MSc students and aim to publish scientific papers and protect intellectual property.

The TINKER consortium comprises 10 companies, three research specialists, one consultancy and a service association, who are major players in the field of semiconductor and microelectronic manufacturing, as well as in the fields of material and process development and industrial fields applying, or interested in applying, additive manufacturing for their needs (Table 1). All the partners have a track record of nationally- and internationally-funded projects in their special research fields.

The TINKER Consortium	
Amires s.r.o.	Inkron Oy
Austrian Standards International	Notion Systems GmbH
Automotive Lighting Italia Spa	P.V. Nano Cell Ltd.
Besi Austria GmbH	Profactor GmbH
Commissariat A L'Energie Atomique Et Aux Energies Alternatives	Robert Bosch GmbH
EV Group E. Thallner GmbH	Sentech Instruments GmbH
Idryma Technologias Kai Erevnas Frt – Foundation for Research and Technology - Hellas	TIGER Coatings GmbH & Co.
Infineon Technologies AG	

Table 1: The TINKER consortium.

Within the first year, the partners in the consortium have made significant progress in creating the proposed TINKER pilot line and the innovative techniques it aims to employ, especially pick and place, inkjet printing and NIL. Partners are working on developing and perfecting designs, processes and materials required for the two selected use cases. They have been able to overcome the obstacles that the COVID-19 pandemic posed and 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. The consortium has made significant progress in equipment and tools development for the TINKER pilot line, and a solid base for achieving the project's ambitious goals is now created. One year after the project's launch, it is well on track to reach its aim of widening the range of available miniaturization and microelectronic fabrication possibilities, and introducing novel approaches to assembly processes, directly in production.

The first public results can be accessed via the project webpage (https://www.project-tinker.eu/downloads/#public_deliverables) and are summarized in three reports. The first report provides a high-level overview about the activities centered on the pick-and-place equipment and shows an early prototype of the RADAR demonstrator. It also touches on the metrology systems that are developed by BESI and SENTECH.

Another report presents the NIL infrastructure and available tools, as well as those developed specifically for the TINKER project. For the realization of LiDAR sensors, the TINKER consortium is developing a NIL-based fabrication method for photonic integrated circuits. The photonic integrated circuit is the very precise core element necessary for the manipulation of light for each LiDAR sensor. The aim of TINKER is to replace certain fabrication steps in an optical phased array (OPA) process flow with NIL in order 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. With the completion of this deliverable, the TINKER consortium has now completed the equipment and tools development for the use case in TINKER.

An important goal is to integrate 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. This is covered in the third report.

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Reference

1. Yole Développement (2021, September 2). LiDAR adoption: Technology choices and supply chain management are the key enablers [Press release]. www.yole.fr/iso_upload/News/2021/PR_LIDAR_AUTOMOTIVE and INDUSTRIAL_MarketUpdate_DesignWins_Yole_September2021.pdf

Biographies

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