PrintedRadar

Additive Druckprozess von Radar 3D Hohlleiter-Antennen zur Unterstützung autonomer Mobilität der Zukunft

Programm / Ausschreibung	Future Mobility Ausschreibung 2022	**Status**	laufend
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Projektbeschreibung

PrintedRadar zielt auf die Erforschung einer additiven Fertigung von neuartigen und effizienten 3D Hohlleiter Radarantennensystemen ab.

In der Radarbrache sind bis dato sogenannte Patch-Antennen, flache Antennen aus leitfähigen Materialien im Einsatz. Diese müssen auf verlustarmen dielektrischen und überaus teuren Substraten (z.B.: Rogers Substrate) hergestellt werden und müssen aufgrund der flachen Geometrie groß sein um negative Beeinflussung der einzelnen Radarkanäle untereinander zu verringern. Neue Entwicklungen zielen auf die Verwendung von Hohlleiter Systemen in Kombination mit 3D Antennen, z.B.: Hornantennen, ab. Solche Designs bieten die Möglichkeit einer Miniaturisierung bei gleichzeitiger Verbesserung der Performance des gesamten Radarsystems.

PrintedRadar verfolgt den Ansatz eine additive Fertigung für 3D Hohlleiter Radarantennensystemen zu erforschen um mit der Entwicklung innovativer Sensorik die Weiterentwicklung automatisierter Fahranwendungen zu beschleunigen. Eine wesentliche Einschränkung gegenüber einem herkömmlichen 3D-Druck Prozesses spielt die notwendige Metallisierung und gleichzeitig hohe Oberflächenqualität der Hohlleiter und Antennen Strukturen. PrintedRadar erforschen die Herstellung von Leichtbau polymer 3D Hohlleiter Radarantennensystemen mittels SLA, DLP und Inkjet Druck mit nachfolgender Metallisierung und der Entwicklung eines Multimaterial Inkjet Druckes um Radarantennensystemen inklusive Metallisierung und Füllung der Strukturen direkt additiv zu Fertigen. Die im Konsortium durchgeführten Simulationen, Erprobung verschiedener Designs, die nachfolgende Charakterisierung und der Vergleich mit State of the Art Systemen, dienen dem nachhaltigen Aufbau von Kompetenzen für Radarsystemen und deren Fertigung. Das hierzu gebildete oberösterreichische Konsortium besteht aus Experten im Bereich Radartechnologie Silicon Austria Labs GmbH (SAL) und Infineon Technologies AG Linz (IFAG), einem Experten für additive Produktionsforschung Profactor GmbH (PRO) und einem Experten für die Entwicklung von Materialien für den additiven 3D Druck TIGER Coatings GmbH & Co. KG (TIGER).

Ein additiver Fertigungsprozess von Radarantennensystemen gewährleistet zukünftig eine schnelle Umsetzung von neuen Designs und deren Erprobung. Dies wird speziell für Anwendungen mit kleinen Stückzahlen interessant wo die

Antennenqualität und Leistungsanforderungen im Vordergrund steht. Potentielle sektorübergreifende Anwendungsbereiche sind Bodenradar-Systeme oder stationären Radar-Systeme.
PrintedRadar dient nachhaltig dem Aufbau von Kompetenzen für Radarsysteme und deren Herstellung basierend auf additiven Fertigungsmethoden.

Abstract

PrintedRadar aims at the research of an additive manufacturing of novel and efficient 3D waveguide radar antenna systems.

So far, so-called patch antennas, flat antennas made of conductive materials, have been used in the radar industry. These antennas have to be manufactured on low-loss dielectric and very expensive substrates (e.g. Rogers substrates) and have to be large due to the flat geometry in order to reduce negative interference between the individual radar channels. New developments aim at the use of waveguide systems in combination with 3D antennas, e.g.: Horn antennas. Such designs offer the possibility of miniaturization while improving the performance of the entire radar system.

PrintedRadar's approach is to explore additive manufacturing for 3D waveguide radar antenna systems to accelerate the advancement of automated driving applications with the development of innovative sensor technology. A major limitation compared to a conventional 3D printing process is the required metallization and at the same time high surface quality of the waveguide and antenna structures. PrintedRadar is investigating the production of lightweight polymer 3D waveguide radar antenna systems using SLA, DLP and inkjet printing with subsequent metallization and the development of a multi-material inkjet printing process to directly additively manufacture radar antenna systems including metallization and filling of the structures. The simulations carried out in the consortium, the testing of various designs, the subsequent characterization and the comparison with state-of-the-art systems serve the sustainable development of competencies for radar systems and their production. The Upper Austrian consortium formed for this purpose consists of experts in the field of radar technology Silicon Austria Labs GmbH (SAL) and Infineon Technologies AG Linz (IFAT), an expert in additive manufacturing research Profactor GmbH (PRO) and an expert in the development of materials for additive 3D printing TIGER Coatings GmbH & Co. KG (TIGER).

In the future, an additive manufacturing process of radar antenna systems will ensure rapid implementation of new designs and their testing. This will be of particular interest for small volume applications where antenna quality and performance requirements are paramount. Potential cross-sector applications are ground penetrating radar systems or stationary radar systems.
PrintedRadar serves the sustainable development of competencies for radar systems and their production based on additive manufacturing methods.

Endberichtkurzfassung

The PrintedRadar project successfully developed and validated a complete process chain for the additive manufacturing of 3D waveguide-based radar antenna systems operating in the 77 GHz automotive band. The work combined design and simulation, material and process development, fabrication, metallization, and high-frequency characterization into a coherent and functional workflow.

A major result is the establishment of a validated design methodology for 3D-printable radar components. This includes linear, bent, and twisted waveguides as well as complex subsystems such as couplers, crossovers, and Butler matrices for beamforming applications. A novel crossover-free Butler matrix architecture was developed, offering reduced complexity, improved manufacturability, and comparable electromagnetic performance to conventional designs.

On the manufacturing side, a reliable SLA-based 3D printing process was implemented, enabling the fabrication of high-resolution radar components with complex internal geometries. In parallel, new UV-curable materials were developed and optimized, achieving improved thermal stability, reduced internal stress, and good printability. Two material formulations showed particularly strong performance and were successfully used for component fabrication.

A key technological achievement is the development of robust metallization processes for 3D-printed structures. Initial dip-coating approaches were replaced by electroless plating and electroplating techniques, resulting in uniform, conductive coatings even inside complex internal geometries. Design adaptations, such as metallization access openings, further improved coating quality and process reliability.

Comprehensive characterization was carried out using a dedicated 77 GHz measurement setup. The fabricated components showed good agreement with simulations, particularly in terms of reflection behavior and functional performance. The final demonstrator, a 4-channel Butler matrix, confirmed the feasibility of the overall approach and demonstrated the potential of additively manufactured radar systems.

In addition, the project established benchmarking strategies and reference demonstrators for comparison with commercial antenna systems, enabling future evaluation of performance and industrial applicability.

Overall, the project demonstrates that additive manufacturing is a viable and promising approach for producing complex, cost-efficient, and high-performance radar components. The results contribute to advancing radar technology for automotive applications and support future developments in compact, lightweight, and resource-efficient sensor systems.

Projektkoordinator

- PROFACTOR GmbH

Projektpartner

- Silicon Austria Labs GmbH
- Infineon Technologies Austria AG
- TIGER Coatings GmbH & Co. KG