DIQACAM

Digital Inspection and Quality Assurance for Lithography-based Ceramics Additive Manufacturing

Programm / Ausschreibung	Produktion der Zukunft, Produktion der Zukunft, 32. AS PdZ - Nationale Projekte 2019	**Status**	abgeschlossen
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Zeitraum	2020 - 2023	**Projektlaufzeit**	40 Monate
Keywords	Additive Manufacturing; Ceramics; Quality Assurance; Process Relability; Digital Manufacturing		

Projektbeschreibung

Das DIQACAM-Projekt zielt darauf ab, die Qualität der Hochleistungskeramiken in der Additiven Fertigung zu verbessern und damit höchste Qualitätsstandards zu gewährleisten, indem ein at- und inline Prozessüberwachungssystem entwickelt wird.
Die Inline-Prozessüberwachung ist ein wesentlicher, derzeit noch fehlender Schritt zur Sicherstellung der Qualität von keramischen Hochleistungsbauteilen, die durch lithographiebasierte additive Fertigung (LCM-AM) hergestellt werden.
Wir schlagen vor, ein neues Qualitätssicherungssystem zu entwickeln und einzuführen, indem wir moderne Sensor- und Bildgebungstechnologien miteinander verbinden: die Optische Kohärenztomographie (OCT) als Technologie für die zerstörungsfreie Prüfung und digitale, bildbasierte Fehlererkennung für die schichtweise 3D-Druck-Prüfung in LCM-AM. Die OCT-Bildgebung im erweiterten Nah- und Mittelinfrarot-Spektralbereich, der sich am besten für die optische Untersuchung von Keramikschichten eignet, kann zusätzlich durch Terahertz- und Laser-Ultraschall-Sensorik zu einem kompletten AM-Keramik-Testsystem erweitert werden.
Die Projektpartner - das österreichische KMU Lithoz GmbH, das österreichische Forschungszentrum für zerstörungsfreie Prüfung (RECENDT) und das französische KMU Leukos werden die Fortschritte bei der Entwicklung von Superkontinuum-Lasern als moderne Lichtquellen bei der Untersuchung von Keramiken nutzen und ins Projekt einbeziehen.
Die LCM-AM-Prozesskontrolle soll dabei auch durch die Einführung eines maschinell-lernenden, bildbasierten Klassifizierungs- und Feedback-System verbessert werden.
Das Ergebnis dieses Projekts wird LCM-AM-Prozesse und Drucker durch eine höhere Prozesssicherheit verbessern, was zu weniger Fehlern und einer geringeren Fehlerquote bei AM-Hochleistungskeramikbauteilen führen wird.

Abstract

The DIQACAM project aims at improving the quality of Additive Manufacturing high-performance ceramics, thereby guaranteeing the highest quality standards, by developing an at- and inline process monitoring system. Inline process monitoring is an essential, currently still missing step to ensure the quality and functionality of high-performance ceramic components, produced by lithography-based additive manufacturing (LCM-AM).
We propose to develop and implement novel quality control by connecting advanced sensor and imaging technologies, i.e. Optical Coherence Tomography (OCT) for non-destructive testing and digital defect identification for layer-by-layer 3D print

inspection in LCM-AM. OCT imaging in near- and mid-infrared spectral range, which is most suitable for ceramic layers, can be extended here by Terahertz and Laser-Ultrasound sensing to provide a complete AM ceramics testing system.
The project partners - the Austrian SME Lithoz GmbH, the Austrian Research Center for Non-Destructive Testing (RECENDT), and the French photonics SME Leukos - will make use by including the latest advances in supercontinuum (SC) lasers for non-destructive testing of ceramics. The LCM-AM process control will also be improved by the introduction of image-based surveillance, as well as machine learning-based defect classification and feedback.
The outcome of this project will enhance LCM-AM processes and printers by increasing process reliability, resulting in fewer defects and a lower fault ratio in AM high performance ceramic components.

Endberichtkurzfassung

The DIQACAM project aimed at ensuring the highest quality in 3D printing of LCM ceramics. To achieve this goal, a mid-infrared (MIR) optical coherence tomography (OCT) system was developed, tested, and integrated as a novel sensing prototype.

The DIQA MIR-OCT setup was successfully demonstrated in (1) a portable, at-line operating mode and (2) an integrated version for in-line monitoring . The at-line prototype showed excellent results and enabled the detection of micro-defects in the printed structures, such as air voids, porosity variations, delamination, or geometrically misprinted layer structures. The described micro-defects have been detected in green and sintered ceramic components . The target ceramic materials were primarily alumina and zirconium dioxide. However, embedded metallized microstructures in glass ceramics (and their defects), for instance, can also be well detected and identified with the new MIR-OCT system. Inline integration of the developed prototype was challenging for the DIQA system, especially due to printer machinery conditions, such as vibrations during 3D printing and the state of the green parts . The feasibility of inline integration was tested in a proof-of-principle manner and an adapted prototype was implemented with project partner Lithoz to enable continuous monitoring in a 3D printer.

A prototype technical imaging and data collection system was enhanced using machine learning methods for automatic analysis and classification . A transfer learning-based model for quality and defect classification has been trained and tested. It allows to give feedback when the percentage of defects exceeds a threshold value set by the operator.

The distinctive results of the project provide technical novelty and utility for the additive manufacturing ceramics community as well as for advances in non-destructive testing methods. The results obtained were converted and presented in journal publications and conference proceedings. The DIQACAM project has enabled an increase in knowledge in the emerging field of MIR sensing in general by incorporating new light sources (MIR supercontinuum laser source, optimized by project partner Leukos), sensor and detector concepts, as well as AI-driven data analysis, incorporated by partner RECENDT .

DIQACAM has paved the way for possible automated defect detection, quality assessment and empowerment of digital 3D printing of ceramics.

Projektkoordinator

- Research Center for Non Destructive Testing GmbH

Projektpartner

- Lithoz GmbH
- LEUKOS