Development of ceramic and multi material components by additive manufacturing methods for personalized medical products

Informe

Información del proyecto

CerAMfacturing

Identificador del acuerdo de subvención: 678503

Sitio web del proyecto

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Coordinado por FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V.
Alemania

Este proyecto figura en...
Periodic Reporting for period 2 - CerAMfacturing
(Development of ceramic and multi material components by additive manufacturing methods for personalized medical products)

Período documentado: 2017-04-01 hasta 2018-09-30

Resumen del contexto y de los objetivos generales del proyecto

Goal of the CerAMfacturing project was to develop a completely new approach for ceramic multi material additive manufacturing which allow series production of customized and multifunctional components for manifold applications. Key to project success was the development of AM machines. The project was focused on collaboration with both, machine and process developers. Demonstrators for personalized medical and consumer products (a IR-heater, a spinal implant, a partial knee implant, a surgical micro gripper, and a customized watch case) were manufactured and validated under practically relevant conditions.

The main outcomes of the project were:
• three newly developed additive manufacturing machines for multi material approaches
• four multi material demonstrators for personalised medical products and one consumer product for individualized jewellery
• technical equipment for combining AM steps with conventional ceramic shaping routes
• appropriate control methodologies
• novel production lines
• a simulation route for FFF of feedstocks

New machines and processes have been developed and evaluated during the project. A combination of AM techniques with conventional shaping methods has been shown to be possible and may help in future to individualize large series components. The project results also show that further research and development efforts are compellent necessary for taking the additive manufacturing methods onto a really productive level.

Trabajo realizado desde el comienzo del proyecto hasta el final del período abarcado por el informe y los principales resultados hasta la fecha
Initially, in case of medical implants, Magnetic resonance spectrography data had be transferred into CAD files. The development of tailored polymeric systems for the FFF (Fused Filament Fabrication) and T3DP (Thermoplastics 3D Printing), and for the LCM (Lithography based Ceramic Manufacturing), was the base for the following process development. Different multicomponent formulations were designed and tested. For all three AM techniques existing devices which are suited for single material applications were further developed and equipped with necessary features for solving the project tasks.

Zirconia and stainless steel are well suited for the desired metal/ceramic composites. For the combination of black and white zirconia two differently colored powders were used, which have nearly the same shrinkage behavior during sintering. The combination of both AM methods, FFF and T3DP with conventional shaping methods like injection molding could be carried out successfully.

The customised IR heater offers the possibility of manufacturing a product which is unique and technically unachievable by traditional processes. The IR heaters record a reasonably low ohmic resistance. In comparison to standard cast ceramic IR heaters, this heater is of a smaller dimensional shape then would be manufactured using casting. Given that the small heater can then operate at a relatively high temperature this could be a solution for many markets.

The spinal cage geometry was revised considering printing process and later mechanical testing. Two varieties were designed. It was proofed that it is possible to print such an extreme cage geometry. Moreover, cost estimation was carried out.

For the partial resurfacing knee implant (PARES) real patient data had been analyzed and one model was chosen to be used to design patient-specific implants. It consists of two regions - the partial resurfacing surface made of solid material which needs a post-treatment by grinding and a trabecular structure for improving the osseointegration of the implanted part.

A special feature for additive manufacturing of the unicondylar knee implant was the so called “2D-structure” on the inner surfaces to facilitate osseointegration of the implanted part. The unicondylar geometry shows all the features necessary to prove its functionality.

For the micro surgical gripper the initial requirements are taken from the benchmark laparoscopic ligation instrument. Due to the challenges of printing and curing conductive zirconia by LCM it has been agreed to focus on printing the demonstrator parts with a combination of zirconia and stainless steel by T3DP. The biggest challenge for manufacturing with T3DP was the high resolution difference between the stereolithography-based manufacturing process and Thermoplastic 3D-Printing.

The watch case consists of a white watch bezel with black numbers. The demonstrator has been made by T3DP again. The multi-color components could be sintered nearly defect-free.

A project website has been established under the domain [http://www.ceramfacturing.eu/](http://www.ceramfacturing.eu/).

A 1st Project Conference related to special work packages took place in March 2017 connected with the Young Ceramists Additive Manufacturing Forum (yCAM) in Berlin organized by the German Ceramic Society (DKG) addressing especially young scientists.

The 2nd Project Conference was focused on hybridization of materials and processes by using Additive Manufacturing methods for attaining multifunctional products and took place on April 11th, 2018 as a session of the Annual Conference of the DKG.

The Industrial Workshop of the project took place at Fraunhofer IKTS in Dresden on October 24th, 2017. It provided special information to European SMEs on the AM technology, multi materials approaches, and combination of AM technology with conventional shaping methods. 45 attendees
from 6 European countries attended the workshop.
Many open source publications in technical journals, press releases and fa

Avances que van más allá del estado de la técnica e impacto potencial esperado (incluida la repercusión socioeconómica y las implicaciones sociales más amplias del proyecto hasta la fecha)

The project consortia bundled the competencies of two AM machine developers in the field of suspension-based ceramic AM methods and feedstock developers for removing existing obstacles. The project results will push AM machine developers, component producers and end users to a clear competitive edge in Europe and will offer them a unique selling proposition on the global market. An article entitled “Towards a future of personalized multifunctional components” has been submitted for the Spring edition 2017 of IMPACT, Pathways to innovation, published on IngentaConnect (the world's largest platform for scholarly information receiving over 1.5 million visits a month and used by over 30'000 institute libraries).

The project movie has been uploaded to the youtube channel https://www.youtube.com/watch?v=1hdZl9hM6-I. Until today 845 visits of the video could be registered.

A strong impact is expected from the three open access publications in the Journal of Visualized Experiments (JoVE) connected with three video clips. The movies have been shut in October 2018.

• JoVE57943 Additive Manufacturing of functionally graded ceramic materials by Stereolithography
• JoVE57693 Fused Filament Fabrication (FFF) of metal-ceramic components
• JoVE57538 Multi-material ceramic-based components - Additive Manufacturing of black-and-white zirconia components by Thermoplastic 3D-Printing (T3DP)

Two patent applications have been filed as common applications from two partners of the consortium each.
Project Consortia at the Meeting in Brussels

Micro surgical gripper, ceramic part with supporting structure
Knee condyla implant

LCM device
IR heater, opened after sintering

Industrial Workshop, Oct. 2017, Dresden
Watch bezel with black zirconia numbers

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