

PROJECT BACKGROUND AND PURPOSE

Additive manufacturing (AM) enables a **new manufacturing paradigm**, such as the rapid, distributive manufacture of complex objects. Additionally it has the potential to reduce waste and to manufacture individual products anywhere in the world, and to customise each of them.

The new EU Framework Programme for Research and Innovation (Horizon 2020) foresees Europe to compete at the forefront of the AM revolution, which in the long term will lead into entire new production and consumption paradigms

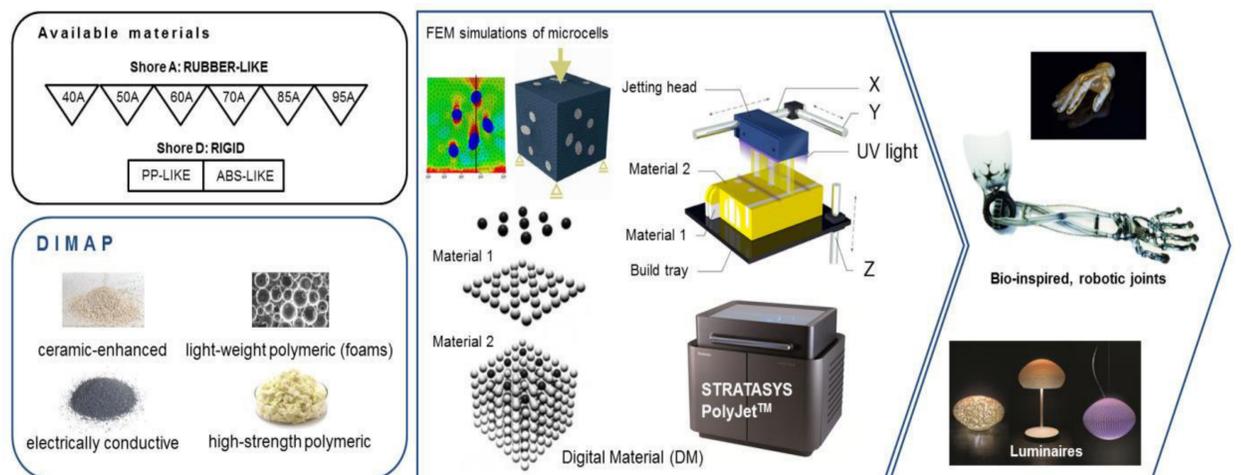
The DIMAP project focuses on the **development of novel ink materials** for 3D multi-material printing by **PolyJet technology**. We will advance the state-of-the-art of AM through modifications of their fundamental material properties by **mainly using nanoscale material enhanced inks**. This widens the range of current available AM materials and implements functionalities in final objects. Therefore applications will not be limited to rapid prototyping but can be used directly in production processes.

DIMAP Application Fields

DIMAP will show this transition in two selected application fields: the production soft **robotic arms/ joints** and **customized luminaires**. In order to cope with these new material classes the existing PolyJet technology is further developed and therefore improved. With the development of **novel ink materials** based on **nanotechnology** improvement of the **mechanical properties** (ceramic enhanced and high strength polymeric inks), the **electrical conductivity** (metal enhanced inks) and the **weightiness** (light weight polymeric materials) are achieved. Based on the voxel printing by PolyJet these new materials lead to a huge broadening of the range of available digital material combinations. Further focus points during the material and **printer development** are **safe by design approaches**, work place safety, risk assessment, collaboration with EU safety cluster and life cycle assessment. An established roadmap at the end of project enables the identification of future development needs in related fields order to allow Europe also in the future to compete at the forefront of the additive manufacturing revolution.

DIMAP GOALS

- Additive manufactured joints
- Additive manufactured luminaires
- Ceramic enhanced materials
- Electrically conducting materials
- High strength polymeric materials
- Light weight polymeric materials
- Novel multi-material 3D-printer
- Safe by design approach



PROJECT CONSORTIUM

The DIMAP project, which began on 1 October 2015, has a run time of 36 months (project close: September 2018).

PROFACTOR is responsible for the project management, the coordination of dissemination and exploitation activities, the development of curing strategies and the support of in terms of inline process control and robotic arm control.

stratasys a leading 3D printing equipment and materials manufacturer, is responsible for the method development of the printing process and the design and construction of a 3D printer prototype.

KIT is responsible for the coordination of requirement definition at the beginning of the project, the development of ceramic nanoparticle enhanced inks and nano-safety assessment.

The main task **BOREALIS**, a leading provider of innovative solutions in the fields of polyolefins, base chemicals and fertilizers, is defining the requirements, the development and characterisation of light-weight polymers and foamable nanoparticle synthesis.

TIGER Coatings, a well known manufacturer of customised functional inks, is responsible for the development of ceramic based inkjet inks or master batches, the technical characterisation of the inks, the jetability and the design-transfer process of the developed inks to the production.

FESTO a leading world-wide supplier of automation technology and pneumatic products and will deal with the development of design-strategies and the evaluation for 3D-printable bio-inspired joints.

PHILIPS Lighting, one the world's leader in Lighting, will develop design-strategies and evaluated 3D-printable luminaires including PCB devices.

JKU is responsible for the development of foamable core-shell nanoparticle synthesis and the characterisation of their functional properties, for simulation and characterisation of mechanical and physical properties of the inks, for consulting in design strategies for bio-inspired joints and for simulation tool for digital materials.

The main tasks of **SOREQ** NRC are high strength polymer based ink development and characterisation.

cirp is responsible for 3D printing of design-studies, final demonstrator and evaluation of final prototype in view of exploitation.

pvnanocell will develop electrically conductive materials/inks.

TEONAN is responsible for the ceramic-nanoparticle synthesis and their functionalization with different dispersants to achieve dispersions with high quality contributing to the development of ceramic ink.

WP 3 Introduction

WP 3 is responsible for the development of new photocurable inks with enhanced physical properties suitable for the PolyJet printing technique. As defined by the industrial partners - Philips and Festo - a particular focus is set on the adjustment of the thermomechanical properties as well as on the thermal conductivity after printing and curing. The property tailoring shall be achieved by the addition of ceramic nanoparticles like alumina to a curable monomer mixture meeting the requirements for the printing and curing processes (very low viscosity, fast curing behaviour even under the presence of oxygen) as well as for the aspired physical properties after curing as function of the ceramic load in the solid polymer-nanoparticle-composite.

WP Goals, tasks and requirements

The goal of this WP is the development of new printable photocurable inks using different monomer mixtures, filled with suitable nanoparticles like alumina for the tailoring of the mechanical properties (e.g. Young's modulus, CTE, tensile strength, elongation at break) or aluminum or boron nitride as well as silicon carbide for thermal conductivity adjustment of the printed and cured nanocomposite. The process chain is completed by investigations on the ink stability and simulation of the aspired physical properties. The scientific work in WP3 is distributed in 5 tasks covering the main goal comprehensively: (see Figure 1)

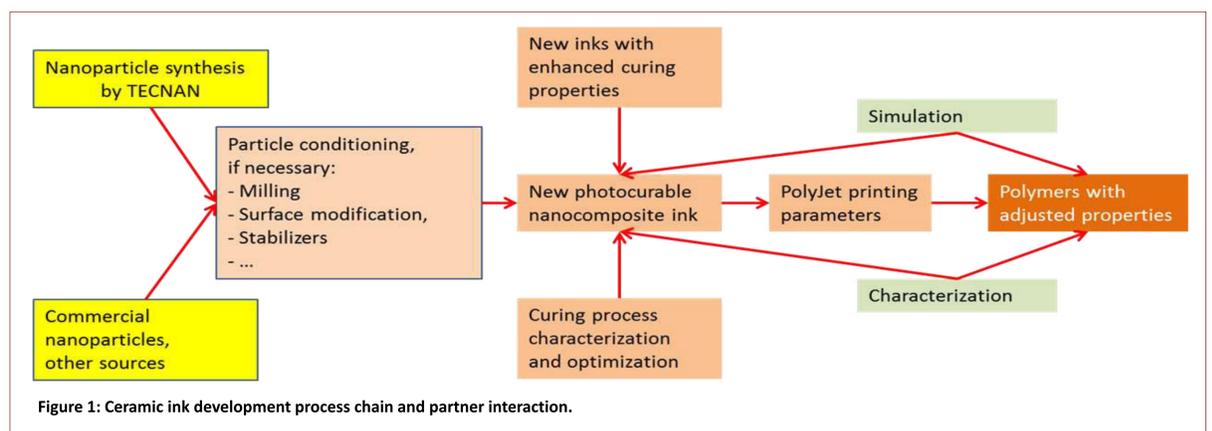


Figure 1: Ceramic ink development process chain and partner interaction.

Intermediate results

In accordance to the WP3 process chain alumina and zirconia nanoparticles of different particle sizes were synthesized by TECNAN. AT KIT these nanoparticles were dispersed in an photocurable monomer matrix and the resulting inks used for first inkjetting trials. The basic curing behaviour is investigated at PROFACOR. The mechanical properties of the cured dispersions were tested at JKU, at present the dogbone specimen shows a pronounced brittleness. Using a different ink prepared by TIGER, first printing tests applying the PolyJet approach at STRATASYS were successfully carried out (see Figure 2).

Name	Matrix material	Filler material	Filler: average particle size [nm]	Filler content [Vol%]	Stabilizer	Stability in monomer [h]	Filterability (5 µm)	Printing tests
Ink 1-PM	EGDMA	Al ₂ O ₃ (TEC)	13	2	TODS	>>2	Yes	Conducted
Ink 2-PM	EGDMA	ZrO ₂ (TEC)	15	1.5	TODS	>>2	Yes	Conducted
Ink 3-PM	EGDMA	Al ₂ O ₃ (TEC)	35	9.1	TODS	>>2	Yes	Conducted

Investigated new inks including printing tests using a PixDro LP50 inkjet printer

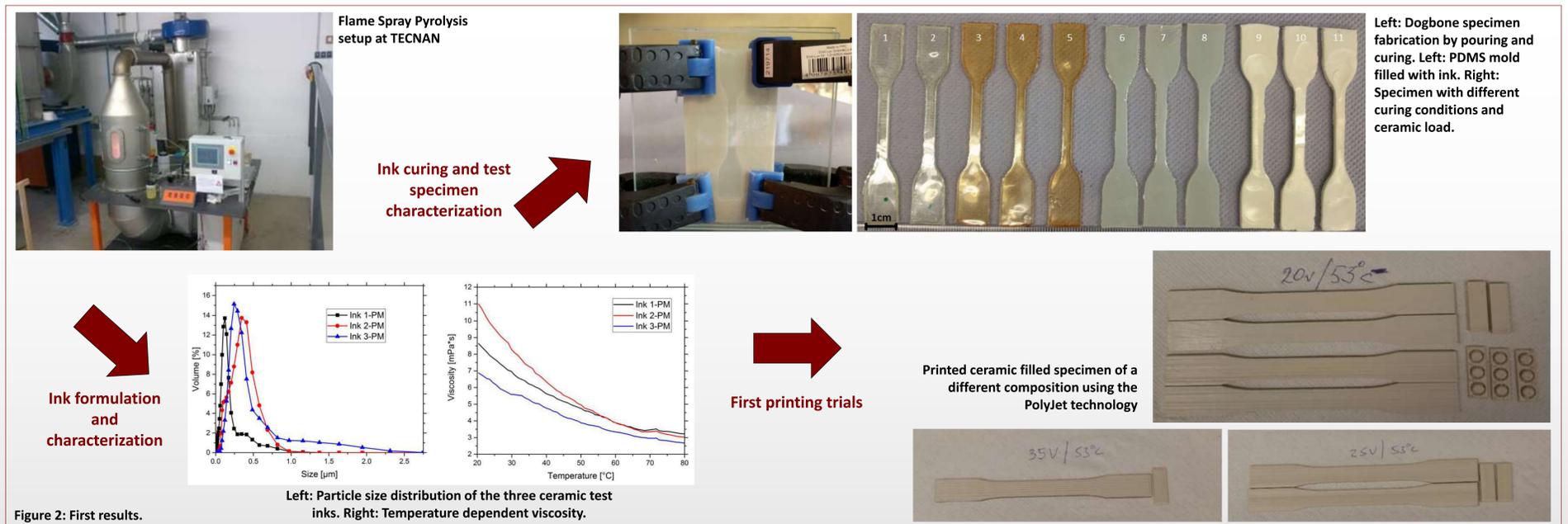
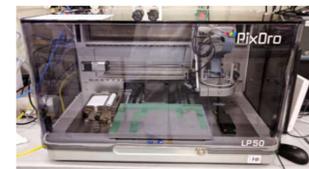


Figure 2: First results.

Outlook

The WP3 process chain has been validated mainly with experimental work. Actually, future research work follows this approach improving the nanoparticle synthesis, the printability applying the PolyJet technology, the ink's curing behaviour as well as the adjustment of the polymer's thermomechanical properties.

References

- [1] T. Hanemann, D.V. Szabó, Polymer-Nanoparticle Composites: From Synthesis to Modern Applications, Materials, 3, 3468-3517 (2010), doi: 10.3390/ma3063468.
- [2] T. Hanemann, P. Bollgrün, B. Khatri, K. Lappe, T. Müller, D. Nötzel, Material development for additive manufacturing, AddIt 2016, Symposium on Additive Manufacturing and Innovative Technologies, Steyr, A, September 29-30, 2016.



WP Introduction

UV curable nano particle silver ink is being developed within the scope of WP4 of the DIMAP project, with the purpose of enabling PolyJet manufactured parts the functionality of electrical conductivity. Project challenges include: (i) Realizing a high solid metal content ink in a monomer matrix with jettable properties; (ii) Maintaining stable ink properties such as viscosity, particle size, and metal percentage, over time, at ambient storage conditions and during the printing session; and (iii) Achieving UV curable ink compatible sintering technologies for fast and low temperature curing and sintering.

WP Goals, tasks and requirements

The work involves synthesizing a high solid content nano particle ink in a UV curable matrix by carefully selecting and adjusting the formulation constituents to achieve a jettable ink with good stability and conductivity after sintering; developing suitable curing and synthesis procedures as well as testing the influence of the different curing parameters on polymerization; characterizing the printability and physical properties of the ink, the electrical conductivity of the printed patterns, and studying the influence of ink chemistry on the functionality of the inks; simulating the electrical properties by mean-field homogenization based simulation approaches; and finally, upscaling the developed inks, and showing printed and sintered parts with suitable conductivity.

Intermediate results

A basic formulation was developed (Table 2) and screening was performed on a number of additives, surfactants, monomers, co-solvents, photoinitiators and their concentrations in order to achieve the required performance. The optimized ink at this stage meets the requirements of solid content, particle size distribution, viscosity, and surface tension (table 3). The ink has to still be improved in terms of its stability in accelerated sedimentation rate testing (Lumisizer); Currently 0.45 $\mu\text{m}/\text{sec}$ was achieved, although the requirement was set for $<0.38 \mu\text{m}/\text{sec}$. The ink passed a jettability test with Ricoh Gen3 E3 print head at 6 kHz (Figure 1), and jetting latency meets the specifications of $>10 \text{ min}$ (Table 3). Curing and sintering evaluation of the formulations indicated that with UV curing with a high powered LED (Phoseon Firejet), some of the inks achieved resistivity as low as $\sim 5\text{-}10 \mu\Omega\text{cm}$, meeting application requirements (Figure 2).

Table 1. Ink Requirements

Parameter	Requirement
Solids %	$\leq 50\%$ w/w (as starting point)
Particle size	D(50) = 75-90 nm ; D(90) = 95-130 nm
Viscosity	12-20 cP at printing temperature ($<60^\circ\text{C}$)
Surface tension	25-35 dyn/cm
Stability @ Room temperature (1 month) @ 60°C (24 hours)	Viscosity change $\leq 5\%$ Particle size change $\leq 5\%$
Accelerated sedimentation rate	$<0.38 \mu\text{m}/\text{sec}$ @ $T=10\%$ transmission
Jetting	Jetting latency $> 10 \text{ min}$
Curing	UV/IR/Thermal curing, $>90\%$ polymerization
Electrical properties	ρ (10 μm thickness) $<40 \mu\Omega\text{cm}$ (Luminaire) ρ ($<1 \text{ mm}$ diameter) $<10 \mu\Omega\text{cm}$ (Robotic arm)

Table 2. Ink Formulation Composition

Component	%wt.
Ag	50.0
Dispersant	1.1
Monomer	6.3
Photoinitiator	2.0
Co-solvent	40.7

Table 3. Ink Properties

Parameter	Ink I50DM-462U
%Solids (Firing @ 600°C)	50%
Particle size (Lumisizer)	$D_{50}=79 \text{ nm}$, $D_{90}=109 \text{ nm}$
Viscosity (Brookfield spindle 42)	10-17.4 cP @ 25-45 $^\circ\text{C}$
Surface tension (Pendant drop)	34.2 dyn/cm
Accelerate sedimentation rate (Lumisizer)	0.45 $\mu\text{m}/\text{s}$
Jetting (Ricoh Gen3 E3)	Jetting latency $>10 \text{ min}$



Figure 1: Jetting at $\sim 900 \mu\text{m}$ from orifice of Ricoh Gen3 E3 printhead, at up to 6 kHz jetting frequency.

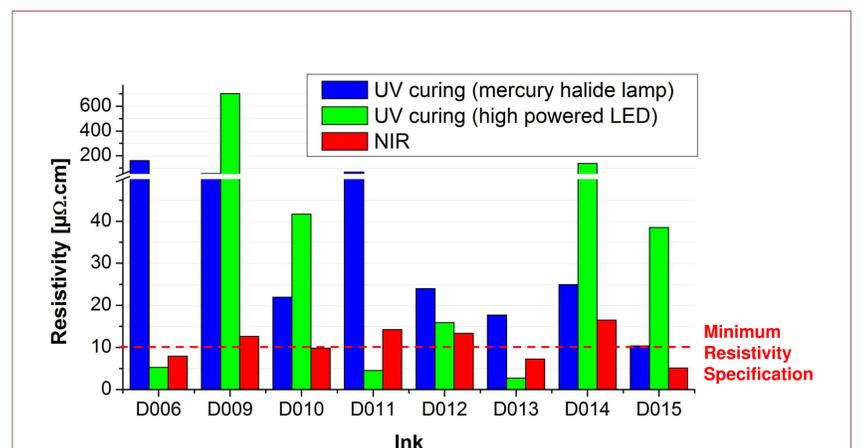


Figure 2: Electrical resistivity of printed silver ink obtained from UV curing with mercury halide lamp (250W, 1min), UV curing with a high powered LED (12W/cm², 1-2 min), and NIR irradiation (20W/cm²).

Outlook

Additional optimizations in the ink formulation are being performed in order to increase the metal content and enhance conductivity of the printed tracks, as well as improve ink stability and jettability at higher printing temperatures. In parallel, the ink is being moulded into specimens in order to characterize the mechanical and electrical properties and mean-field homogenization based simulation approaches will be used to propose an optimum material formulation. Up-scaling of the developed inks will follow, as well as validation of the inks in terms of fulfilment of stage gate criteria. The ink properties will allow incorporation into multi-material 3D printing with PolyJet Stratasys printers.

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WP Introduction

In order to expand 3D printing and make it more versatile, new processes are needed that are able to deposit a broader range of materials, including engineering polymers of different characteristics. Engineering polymers have better mechanical and/or thermal properties than the more widely used commodity plastics (such as polystyrene, PVC, polypropylene and polyethylene). However, engineering polymers, especially polyimides, are not commonly used as inks in additive manufacturing technology. The requirements for development of polyimide-based ink material were determined, addressing both ink-related properties and a specific material properties derived from the concept of design specification and material requirements for robotic arm demonstrator (D2.1) and for luminaire demonstrator (D2). The research includes specific requirements for curing conditions, printing process and ink stability. A polyimide (PI)-like ink was developed for a use as an engineering material with exceptional thermal stability and good mechanical properties such as stiffness, toughness, strength that make them valuable in the manufacture of structural products.

WP Goals, tasks and requirements

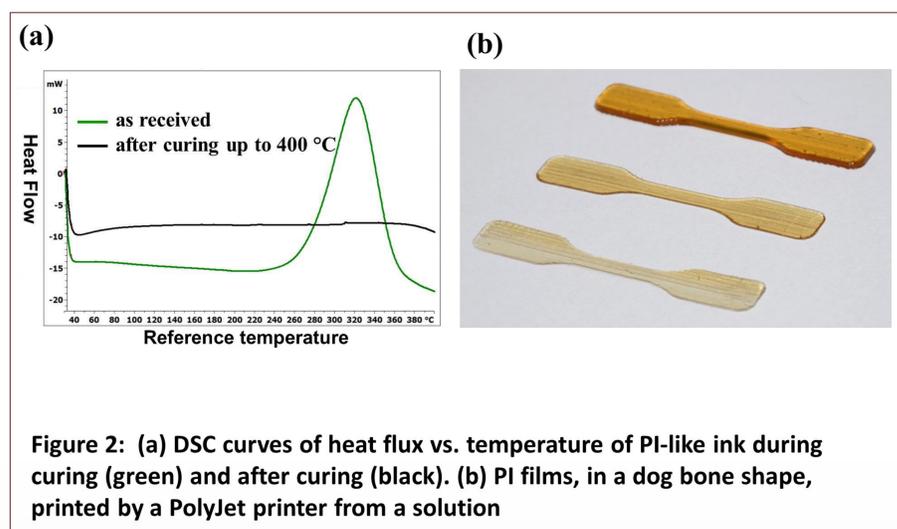
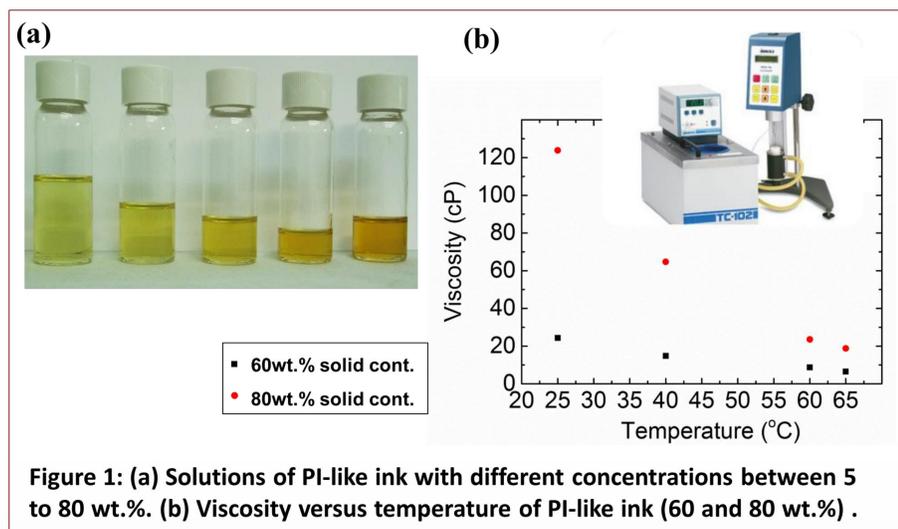
1. Development of polyimide ink for PolyJet 3D printing
2. Development of curing procedure of high strength polymer based inks
3. High strength polymer based ink development and characterization
4. Simulation and characterization of mechanical and physical properties of high strength polymer based inks

Intermediate results

PI-like ink was prepared as clear and homogeneous solution with varying concentrations of precursor materials (between 5 to 80 wt.%) assisting by vortex and sonicator as depicted in Figure 1a. The viscosities of PI-like ink solutions (60 and 80 wt.%) were measured, as displayed in Figure 1b. The viscosity of the PI-like ink, around 20cP, fit the requirements, at temperatures lower or similar to the target jetting temperature (50-70°C).

The thermodynamic properties of the PI-like ink was examined using DSC, as illustrated in Figure 2a, during curing (green) and after curing (black). During the heating process the PI-like ink exhibits exothermic reaction around 320°C, identified as 1st order phase transition temperature. The film, after curing up to 400°C, demonstrated thermosetting characteristic.

PI-like ink was jetted by a 3D printer, Connex 500 by Stratasys, to test the jettability and UV curability of the developed ink formulations for application in PolyJet technology. The printed pattern was a dog bone shape with 4 mm wide neck, as presented in Figure 2b.



Summary

PI-like ink for PolyJet 3D printing was developed as low viscosity, high solid content, and environmental friendly solution. The solutions were characterized in terms of viscosity, uniformity, surface tension, safety, and stability. The solutions were found to fit the constraints and requirements of the PolyJet technology. The novel PI-like ink was tested using a Stratasys 3D printer (Connex 500). For the first time thermally stable PI films were obtained using the PolyJet Technology. The choice of materials and the developed preparation and printing procedures were covered by a provisional application for a patent. The ability to print high-strength PIs will widen the range of the 3D printable materials and advance the state of the art of the 3D technology overall. Due to its unique properties, the novel PI-based ink can be implemented for printing of final objects, and hence PolyJet applications will not be limited to rapid prototyping but it can be used directly in the production processes.

WP Introduction

Foam, a structure made up of a solid, stable compound and a gaseous compound, has one major advantage over solid compounds: it has a very low density combined with high structural robustness. This weight reduction combined with the mechanical properties makes this material a very interesting candidate for 3D-printing. Therefore, the chosen way in DIMAP to fulfil the material requirements for light weight polymeric materials is to directly print polymeric foams. [1,2]

WP Goals, tasks and requirements

The goal of WP6 is to produce an ink system which is foamable after printing. This ink will then be utilized to print parts of a bio-inspired robotic arm. Certain tasks are defined to structure the work package:

- T6.1: Light weight polymers and foamable nanoparticle synthesis (see figure 1 for general experimental setup)
- T6.2: Curing procedure of light-weight polymer based inks
- T6.3: Light weight polymer based ink development and characterization
- T6.4: Simulation and characterization of mechanical and physical properties of light-weight polymer based inks
- T6.5: Light weight polymer based ink stability and upscaling

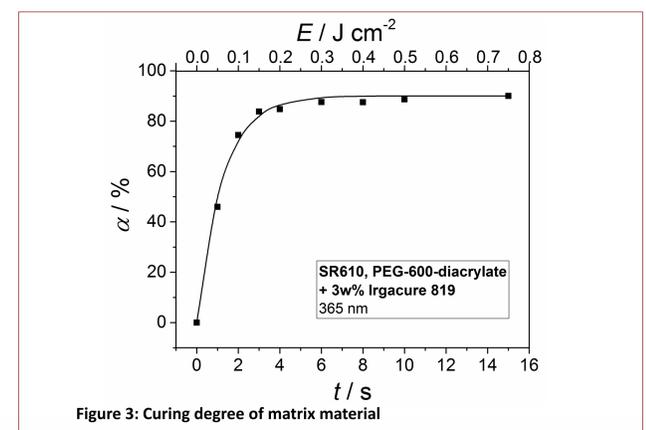
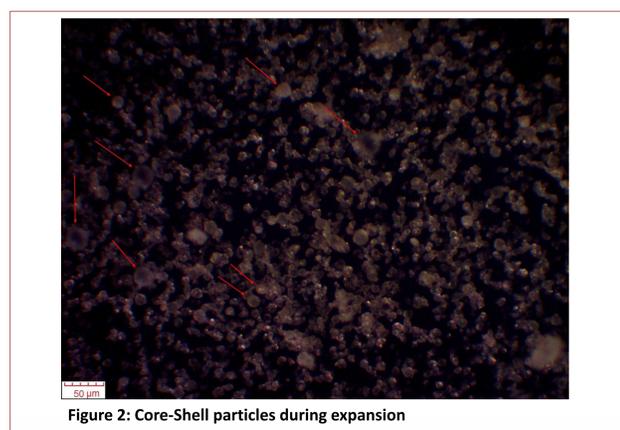
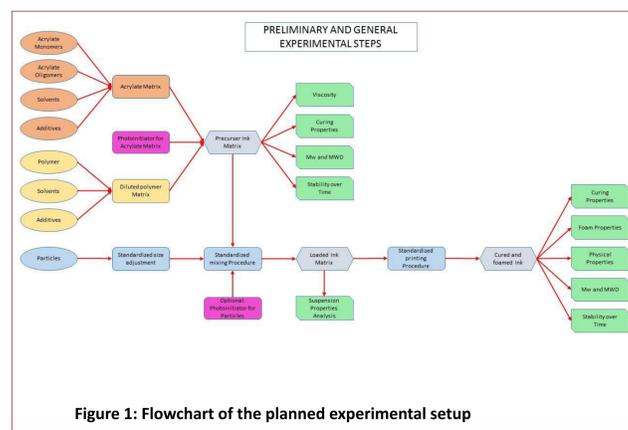
To ensure a successful outcome, the work package effort is split into two experimental setups: utilizing core-shell particles and generating an open cell foam. Core-shell particles, preferably with a diameter smaller than 1 micrometer, are synthesized with a core of physical blowing agent or chemical blowing agent, so that upon energy input, the outer shell will be expanded and a porous lightweight structure can be established.

In the open cell foam approach the blowing agent would be dispersed in the ink matrix and upon adding energy decompose or evaporate, therefore creating the foam structure.

Intermediate results

Principle experiments have been conducted to realize a proof of concept for the different synthesis routes. This has been achieved for the microsphere approach with physical blowing agents. Experiments were conducted with different parameter variations and were carried out as free radical oil in water suspension polymerizations via a known polymerization route. [3] Although the particle size of the produced CSP is still too large to be used in the current printer and printhead setup, this proof of concept will be used as a basis for further advancement of the CSP synthesis. Particles in the state of expansion can be seen in figure 2.

Development of a suitable foaming and curing procedure is an important part of the printing process, as it defines the structure and stability of the printed foam. The curing procedure consists of 3 steps: short low-power UV-irradiation to increase the ink viscosity, foaming of embedded CSP and short high-power UV-irradiation to fully cure the matrix in order to stabilize the formed foam structure. Figure 3 shows the curing degree of a possible matrix material for the light weight polymeric ink during UV-polymerization.



Outlook

With a proven principle of synthesis, the focus now lies in the size reduction of the core shell particles, as well as the development of entirely different ink systems e.g. polyolefin based.

A suitable curing and foaming procedure for different ink systems will be developed to receive high weight reduction together with good stability of the final printed foam structure. For characterization of foam quality, AFM will be used to detect the diameter increase of the foamed CSP.

References

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WP Introduction

Today the PolyJet (PJ) 3D printing technology is one of the major technologies being utilized in commercial 3D printing systems. PJ is based on ink-jet deposition and UV curing techniques and is distinguished by its great versatility, good feature resolution and smooth surfaces, but mostly for its multi-material capabilities that are integrated via multiplicity of ink-jet printing heads. The PJ technology allows printing different resins from different print heads and is easy to scale up for more materials and higher build rates. The ink-jet heads deposit liquid photo-polymer materials, which are then exposed to UV illumination and hardened into thermoset solids. PJ technology allows control over each deposited droplet thus digital programming of the multi-material structures can be achieved. This multi-material 3DP process often serves for fabrication of complex parts structures that comprise of elements of different stiffness, performance, color or transparency. The multi material capability is unique to PJ Technology versus all other 3D printing methods.

The DIMAP project targets additive manufacturing of robotic joints and luminaires by using newly developed ceramic enhanced materials, electrically conductive materials, light-weight polymeric materials and high-strength polymeric materials. 3D printing of these joints and luminaires using the aforementioned multi materials should be achieved by optimized PJ printer design adopted for printing such advanced materials.

WP Goals, tasks and requirements

WP7 is the actual integration of all previous work packages related to the different materials development as well as the process control and safe-by-design tasks into an optimized 3D printer that is capable of manufacturing the designed robotic joints and luminaires. The main objectives of this WP are:

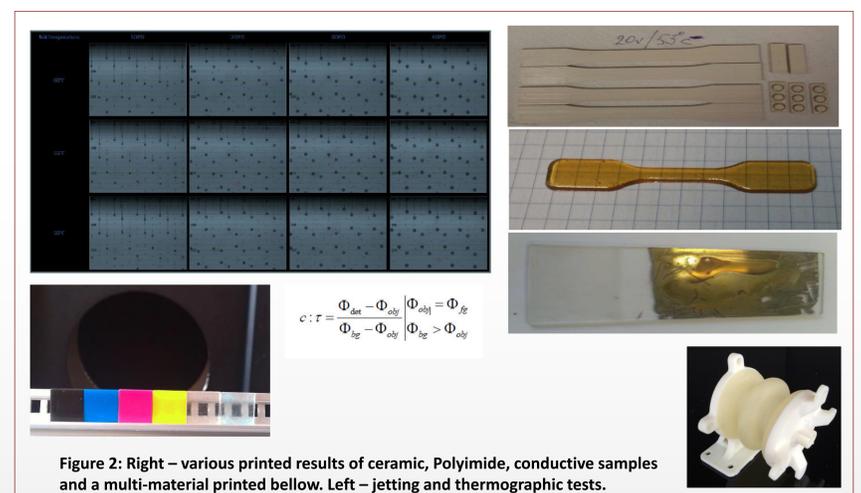
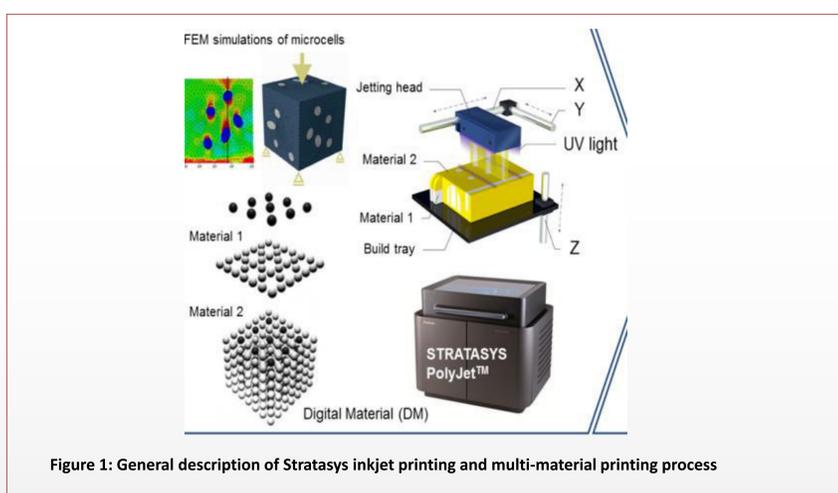
1. Process and technology development and construction of novel multi-material 3D printer
2. Development of simulation tool for digital materials
3. Design, simulation, fabrication and characterization of test structures for digital materials
4. Optimization of developed ink systems

The integration of four completely new and highly advanced materials into a 3D printing process is highly complicated. To minimize further complication if possible the initial target is to optimize the newly developed inks to the current PJ system capabilities. This results in the following ink requirements:

1. Viscosity at jetting temperature 12-20 mPas (60-90° C).
2. Surface tension 25-35 dyne/cm (depending on substrate and used polymer)
3. High solid content in the ink dispersion
4. Newtonian ink flow, stable up to frequency of 10 kHz.
5. Max particle size of D100 = 1-2 micron
6. If unavoidable: environmental friendly and low boiling point solvents (< 180°C), but with low vapor pressure at jetting temperature
7. Hardening of the ink: UV curing, very fast (less than 1 sec)
8. Post process: no in line post process

Intermediate results

- Several initial ink formulations of the new materials were evaluated (Metalic, Ceramic, Polyimide, Nano filled) including printing feasibility for few.
- Few multi materials and digital materials simulations and trials took place, mainly focusing currently on the hard and rubbery structural materials.
- Evaluation of new print heads with ink recirculation system had started in order to mitigate the risk of high viscosity and/or high filler loads.
- An experimental printer was built to allow testing of very small amount of inks and includes: heated tray, hot air flow for solvent drying, UV curing module and thermal (IR) curing module. This experimental printer should allow initial tests of the new materials.
- Various thermography methods were assessed, thermal camera specifications were defined and thermographic measurements of printed objects were done for initial parameters assessment.



Outlook

Successful completion of DIAMP project will demonstrate for the first time the capability of using additive manufacturing to manufacture highly complex functional parts. On top of the above, the newly developed inks and post processes will be a breakthrough in terms of use of functional fillers and solvents as part of the PJ multi material spectrum.

We believe that at the end of the project it will be possible to present an established roadmap that enables the identification of future development needs in related fields in order to push forward the additive manufacturing revolution.



WP8 Introduction

WP8 is focusing on the design, printing and evaluation of 2 demonstrators:

- 3D-printable bio-inspired joint for a robotic arm
- 3D printable luminaires including PCB devices

Before the demonstrators will be printed the proof-of-concept will be shown on proper design studies.

The material requirements for the 2 demonstrators have been defined in detail in WP2 and are the basis for the nano technological material development.

The requirements for the robotic arm focus on high strength, light weight polymeric, ceramic enhanced, mechanically high tensile and electrical conductive materials.

For the luminaires and PCBs optical reflective, electrical conductive, soft bendable non porous and thermal conductive material have been specified.

WP8 Goals, tasks and requirements

WP8 focuses on the design of 2 demonstrators and the development of design strategies which are implicated with their actual printing.

Target is it to take advantage of the multi-material printing technology and maximize functional integration.

Next to pure polyjet printing other design approaches like hybrid manufacturing are evaluated. Those approaches include e. g. a combination of other 3D-printing technologies or moulding methods.

In the iterative design process finite elements methods and parameter optimization methods are applied to maximize material capacity.

Within design studies the interaction of nano-optimized materials and the novel multi-material printer is tested.

Based on the evaluation of the final demonstrators a RTD roadmap will be elaborated.

Intermediate results

Within the current state first design studies for the 2 demonstrators have been printed and evaluated. A first iteration design using finite elements methods and parameter optimization to maximize material capacity has been accomplished successfully.

To evaluate the printing results a hybrid manufacturing approach has been conducted and evaluated simultaneously.



Figure 1: design study for a luminaire PCB
circular design using polyjet technology

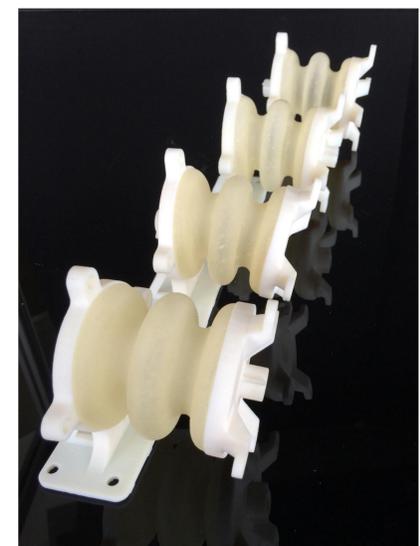
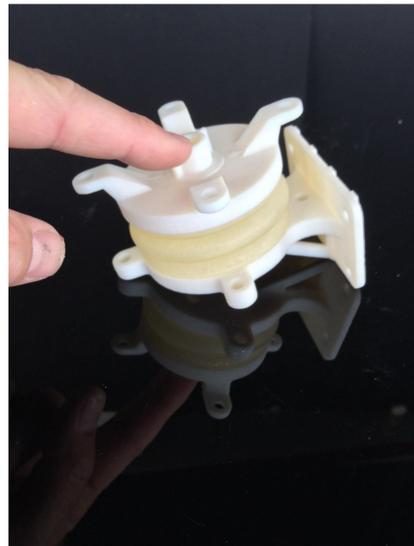


Figure 2: design study for a robotic arm
linear bellow actors for component testing using polyjet technology

Outlook

Within the next months based on the first design studies the design of the final demonstrators will be completed in an iterative process.

The implicated design strategies will be tested depending on the availability of the different nano-optimized materials and the arrival of the newly developed novel multi-material printer at the WP8-leader location (cirp GmbH) within further iterations.



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WP Introduction

Within DIMAP the nanosafety work package 9 will accompany the other work packages in questions concerning the safety issues of the developed (nano)materials, possible exposure hotspots, worker's protection and environmental aspects. In WP9 the project consortium will show the implementation and assessment of a safe by design approach. However, the impact and interaction of nanomaterials on environment and human health are widely discussed today. Within DIMAP (nano)material characteristics will be documented in safety data sheets to ensure transparency and safe handling by all project partners. Furthermore the focus will be on work place safety requirements in close collaboration with the EU Nanosafety Cluster. Risk assessment of the new nanoparticle inks and life cycle assessment of the components will complete the tasks in this WP.

WP Goals, tasks and requirements

The main objectives of this work package are: Implementation and assessment of a safe by design approach (task 9.1), the establishment of work place safety requirements (task 9.2), collaboration with the EU Nanosafety Cluster (task9.3), a risk analysis with risk assessment, risk characterization, risk communication, and risk management (task 9.4), and finally a life cycle assessment of the components (task 9.5).

Intermediate results

Within the DIMAP project various nanomaterials are used in inks for 3-D printing. Safe-by-design assumes the knowledge of the used chemicals / nanomaterials. That is why physicochemical properties of manufactured nanomaterials have to be described first and then generate the basis to understand the toxicity of nanomaterials. Exposure hotspots were identified. A DIMAP SDS-template was developed. Another aspect of the safe-by-design approach is the exposure of humans to nanoparticles during the whole process of AM. At present, little is known about the release of nanomaterials from 3D printers. But the potential exposure to airborne nanomaterials from these printers needs to be measured in the personal breathing zone using nano-specific personal samplers or monitors. Within DIMAP, such a small and easy to use sampler is currently applied to determine the particle release at, in and around the printer. Measurements are carried out in ambient condition as well as with the printer running, being able to compare different materials, different printing techniques, printer models and, to a limited extent, the dependence of exposure on different manufacturing parameters.

DIMAP is partner in the new established Nanosafety Cluster working group: *Safe by Design and Industrial Innovation* (WG9) and supported a survey questionnaire concerning a REACH review.

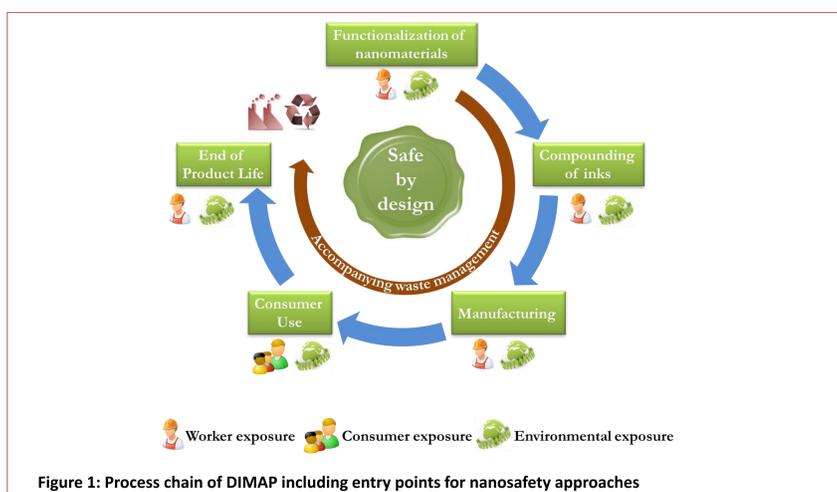


Figure 1: Process chain of DIMAP including entry points for nanosafety approaches

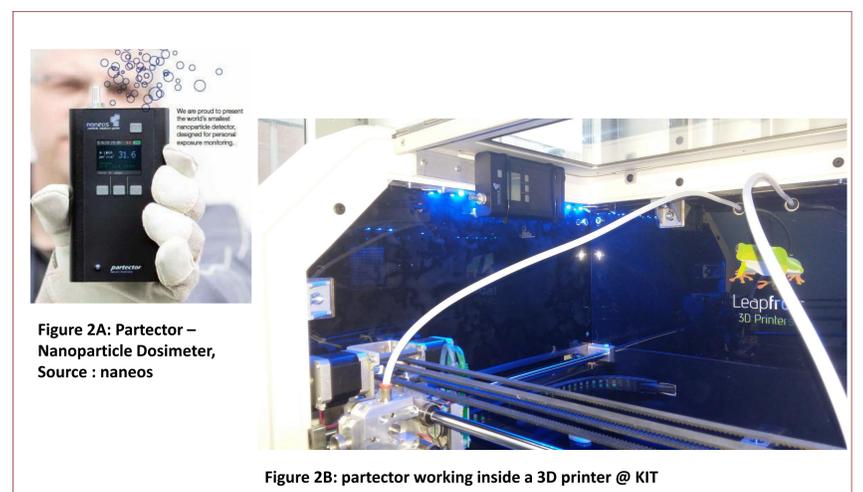


Figure 2A: Partector – Nanoparticle Dosimeter, Source : naneos

Figure 2B: partector working inside a 3D printer @ KIT

Outlook

The main aim of the DIMAP project is to develop novel multi-material systems for PolyJet inks. Therefore, DIMAP will improve and advance the current technology by widening the range of available materials. However, the impact and interaction of nanomaterials on environment and human health is widely discussed today.

Work is currently at an early stage concerning the measurement of (nano)particles in the process chain of additive manufacturing. Different work places have to be analysed and release, exposure to workers, potential hazard and a potential risk have to be assessed. As an outcome of the project a safety guideline will be established in order to support the industry in applying AM in an even wider spectrum.

