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2021 IMAGINENANO

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ABSTRACTS BOOK

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On behalf of the International, Scientific and Technical Committees we take great pleasure in welcoming you to Bilbao for the fifth edition of **ImagineNano**.
Since 2011 **ImagineNano** has strengthened its position as one of the main events dedicated to Nanoscience and Nanotechnology (N&N) in Europe. The outstanding results of participation that have been reached and the interest created by the discussions, have laid the foundations for the upcoming edition.

ImagineNano 2021 is now an established event and is an excellent platform for communication between science and business, bringing together Nanoscience and Nanotechnology in the same place.

Internationally renowned speakers will be presenting the latest trends and discoveries in Nanoscience and Nanotechnology.

Under the same roof will be held 6 International Conferences (QUANTUM, Graphene & 2DM, NanoSpain, IC2, 3DPrinting and 3PM), an exhibition showcasing cutting-edge advances in nanotechnology research and development and a brokerage event (one-to-one meetings).

ImagineNano will gather the global nanotechnology community, including researchers, industry, policymakers and investors. The latest trends and discoveries in N&N from some of the world´s leading players in the field will be discussed.

We would like to thank all participants, sponsors and exhibitors that joined us this year.

The Basque Country demonstrates its strengths in nanoscience, micro and nanotechnology, and positions itself as a major player in the "nano" world, reason why **ImagineNano** is organized for the 5th time in Bilbao.

There´s no doubt that **ImagineNano 2021** is the right place to see and be seen.

Hope to see you again in the next edition of **ImagineNano** (2023) in Bilbao.

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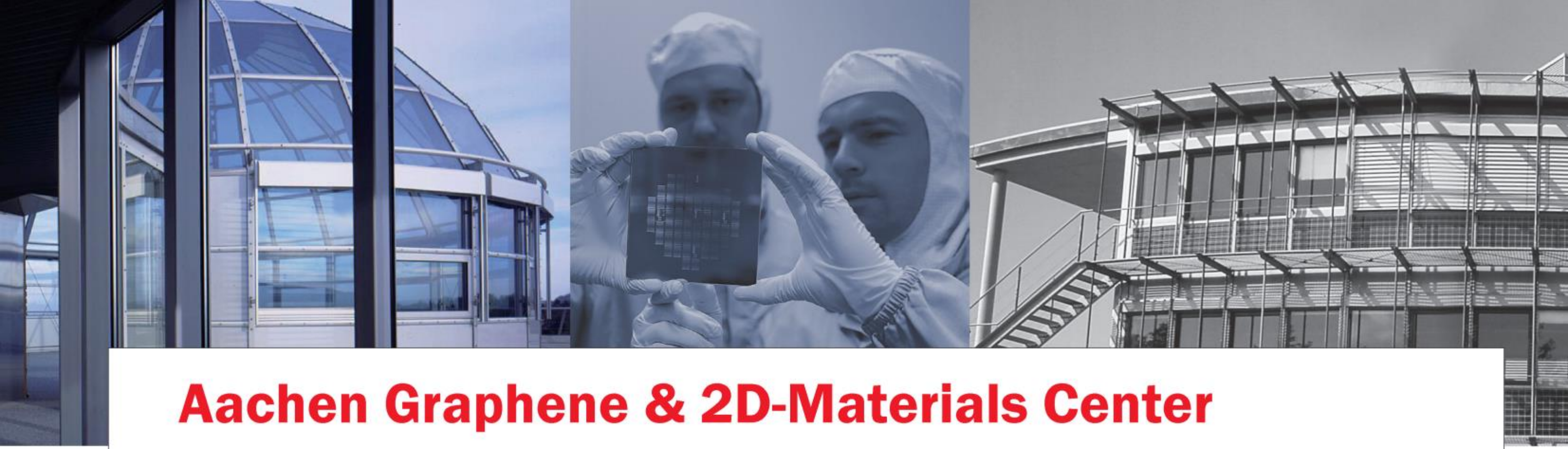

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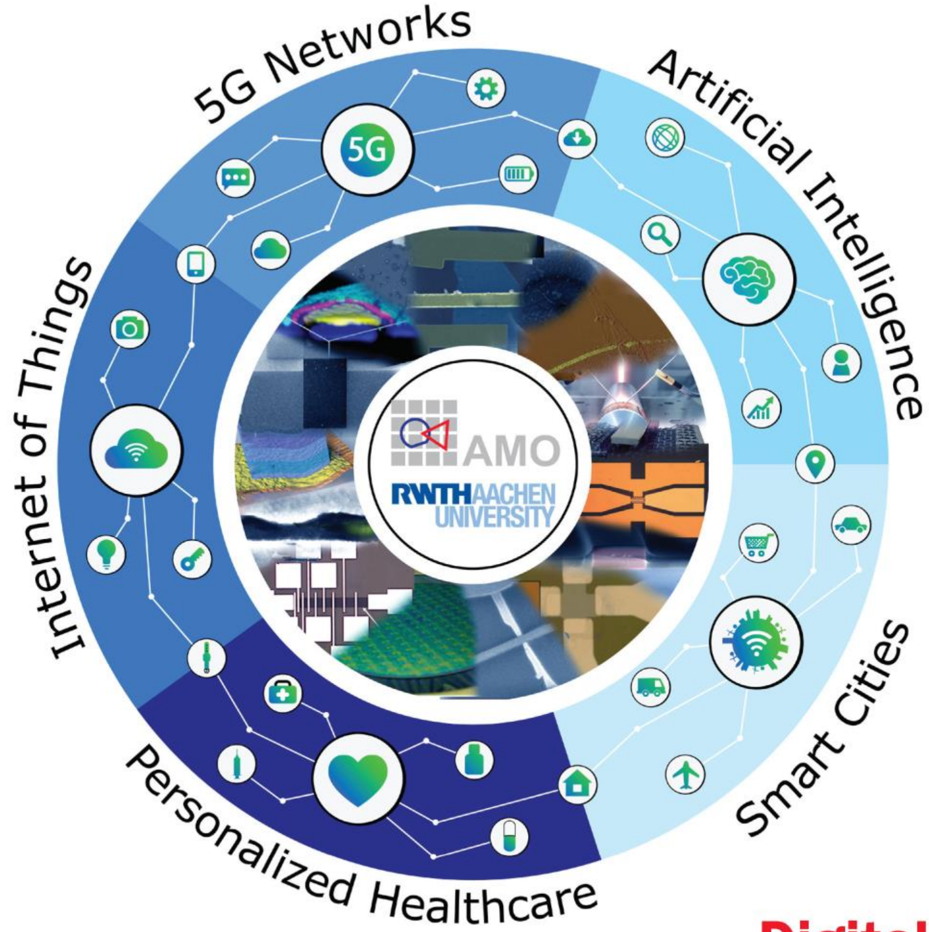

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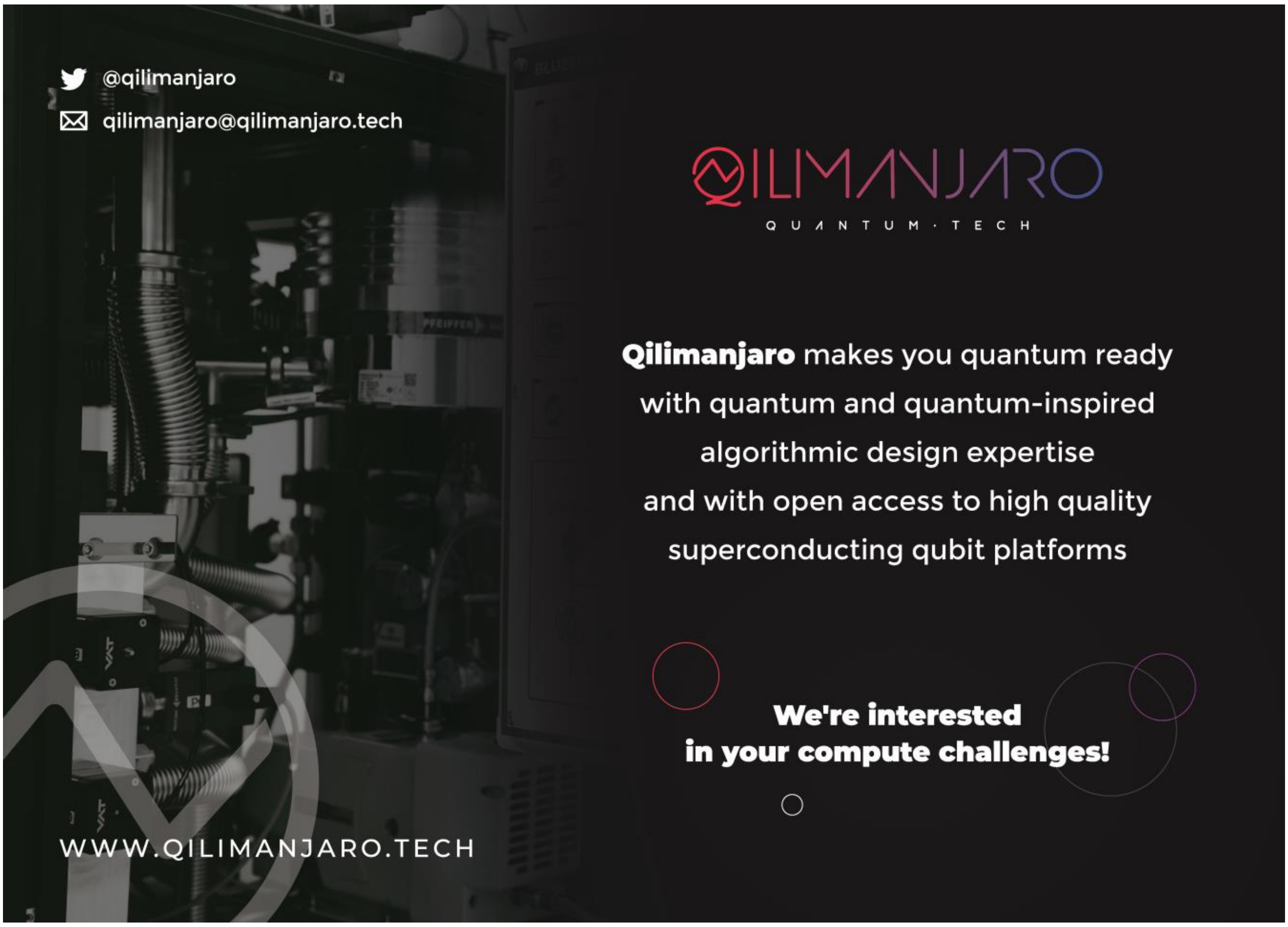

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SPEAKERS

3D Micro and nano engineering of fragile materials

Juergen Brugger

Microsystems Laboratory, EPFL, 1015 Lausanne, Switzerland

http://lmis1.epfl.ch
juergen.brugger@epfl.ch

The manufacturing of silicon micro systems is well advanced because the devices for many societal applications can be fabricated with established methods from IC industry. Polymer-based MEMS have a great potential for flexible electronics and biomedical applications. But we must admit that up to now the techniques to engineer functional polymers into reliable 3D microsystems for daily use are still at their beginning. One reason is that a standardized fabrication platform with the appropriate tools and processes does not yet exist.

This talk will provide an overview of recent achievements in advanced manufacturing at the micro/nanoscale than can be applied in particular to fragile materials, where harsh process steps using charged beams and etch chemistry can be harmful. I will in particular review briefly **nanostencilling** [1] that keeps offering novel opportunities for direct, in-vacuum patterning in particular for organic electronic applications. I will then show a new combination of **3D & inkjet printing** for creation and precise filling of micro-containers [2]. **Local thermal processing** [3] of silk [4] is introduced as a new, water-solvable resist. Finally, **capillary based self-assembly** [5] of nanoparticles is shown to form metallic dimer structures with controlled nano-gabs. All these techniques form part of the gentle toolbox for future micro/nano-manufacturing of fragile material systems, combining top-down and bottom-up techniques. One of the open challenges is to define mix-and-match strategies using the individual techniques.

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[3] S. Howell et al. Microsystems & Nanoengineering (2020)
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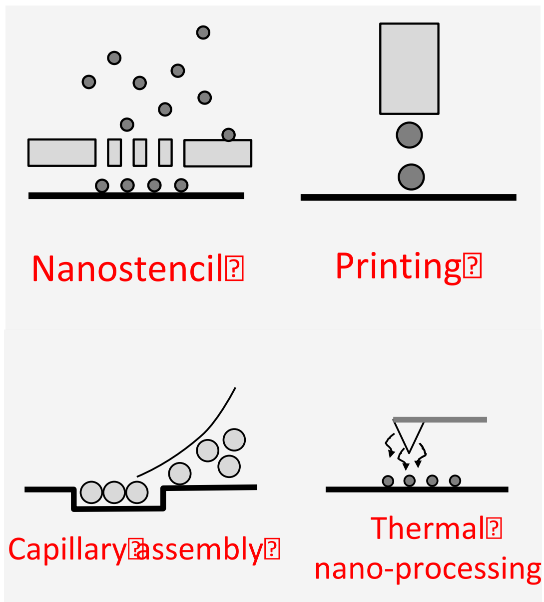

Figure 1: Schematic of 4 key techniques enabling patterning fragile material systems.

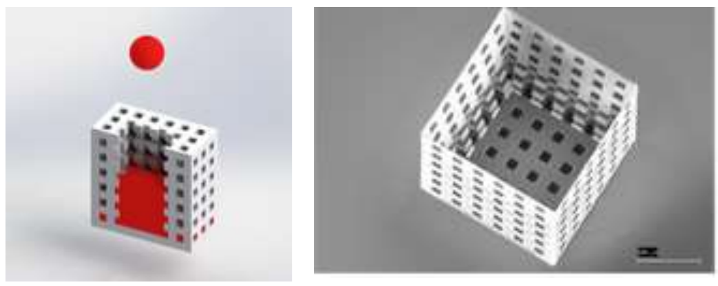

Figure 2: Schematic (left) of 3D printed scaffold ~250 micrometer side length to be filled with inkjetted drug and SEM image (right) of 3D printed scaffold before filling

Industrial Additive Manufacturing - a user perspective

Ulli Klenk

Siemens AG (Germany)

At Siemens Power and Gas we are utilizing the benefits of Additive Manufacturing to increase our customers satisfaction, enhance our products and optimize our processes along the entire value chain from R&D to services. Thereby we are using AM for our entire portfolio, from the compressor through the combustion to the turbine applications of our entire fleet. Based on these high-end applications and the connected requirements, we are driving the transfer of established industrial standards and certificates also to the AM technologies. Hence, we expect open and transparent AM systems, allowing us to access and influence all available data at all times online in real-time; just as in other established industries e.g. Pharma, F&B and semiconductor. These open systems shall be connected into production lines, with vertically and horizontally totally integrated automation solutions and also seamlessly integrated into one end-to-end PLM ecosystem. A holistically digitalized ecosystem, with one integrated CAx Plattform beyond the classical CAD-CAE-CAM mindset and with one data format. In AM all three disciplines consistently affect one another and hence must be considered and represented simultaneously to enable disruptive, generative, and more efficient topologies. Innovative Topologies increasing the overall efficiency of our turbines and therefore also enabling us to contribute to society, by fostering the global reduction of CO2 emission.

Development and applications of printable polymer based smart and multifunctional materials

S. Lanceros-Mendez

BCMaterials, Basque Center for Materials, Applications and Nanostructures, UPV/EHU Science Park, 48940 Leioa, Spain

IKERBASQUE, Basque Foundation for Science, 48013 Bilbao, Spain

Senentxu.lanceros@bcmaterials.net

Abstract

Close related to the strong evolution of the Internet of Things (IoT) and Industry 4.0 concepts [1], enabling new services and production paradigms, smart and multifunctional materials are a key driving force for the development of wireless, sustainable and interconnected systems [2]. Thus, printed smart materials is an area of increasing interest due to low-cost fabrication, simple integration into devices and possibility of obtaining multifunctional materials over large and flexible areas1. The impact of printable smart and multifunctional materials span from the areas of sensors and actuators [2], to energy generation [3] and storage [4] and tissue engineering applications [5], among others. The present talk will summarize the main features, achievements and the challenges associated with various printing technologies. Further, the most relevant smart materials that are already being printed, mainly piezoelectric, piezoresistive and magnetostrictive will be discussed together with some representative applications. Finally, critical challenges and future research directions will be indicated.

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Acknowledgements

Spanish Ministry of Economy and Competitiveness (MINECO) through the project MAT2016-76039-C4-3-R (AEI/FEDER, UE). Basque Government Industry and Education Department under the ELKARTEK, HAZITEK and PIBA (PIBA-2018-06) programs, respectively.

Mechanical and microstructural study of titanium alloy (ZTi-Powder® and ZTi-Med®) via additive manufacturing

Amine HATTAL
Jean Jacques Fouchet

Z3Dlab, Parc Technologique, 26 Rue des Sablons, Montmagny 95360, France

ahattal@z3dlab.com/jjfouchet@z3dlab.com

Ti64 alloys have been widely used for aeronautics and biomedical implants because of their superior corrosion resistance and mechanical properties. For instant, Ti64 is already used in aircraft engines however it represents only 15% of its uses in classical engines due to insufficient strength, low hardness, and poor wear performance at high temperatures. Titanium matrix composites (TMC) however seems to present the best combination of ceramic hardness and wear resistance and the softness of titanium matrix. ZTi-Powder® (Figure 1) is a TMC material developed by Z3DLAB in order to overcome the drawbacks of Ti64 alloy, mechanical properties showed interesting results[1,2] hardness increased by almost 80% without drastic reduction in ductility and high mechanical resistance at high temperatures was observed.

Ti64 is also widely used in the medical field such as dental implants and medical devices. However, many studies reported that unsatisfactory loads transfer from the implant devices and the relatively high elastic modulus of implant materials may lead to bone resorption. To overcome these issues, Z3DLAB developed a new dental implant design (DNA implant) and results showed that 84% of the implant's internal volume was colonized by bone cells. These results led to a publication in Helion journal [3]. Also, Z3DLAB developed a new titanium alloy ZTi-Med® (Figure 2) and achieved the lowest elastic modulus using Selective laser additive manufacturing technology (SLM). being very close to that recorded for the human bone (25GPa).

References
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[3] A.-F. Obaton, J. Fain, M. Djemaï, D. Meinel, F. Léonard, E. Mahé, B. Lécuelle, J.-J. Fouchet, G. Bruno, Heliyon 2017, 3, e00374.

Figures

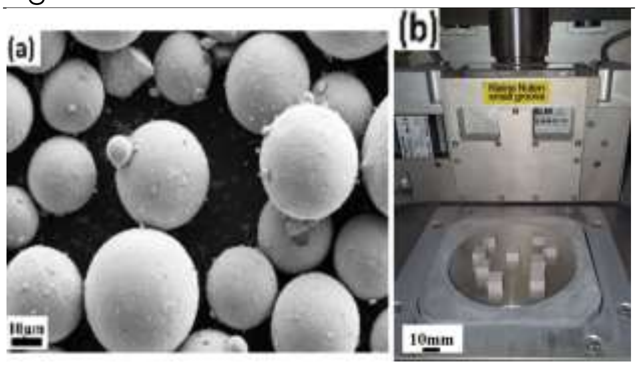

Figure 1: (a) ZTi-Powder starting materials (b) SLM manufactured parts of ZTi-Powder®

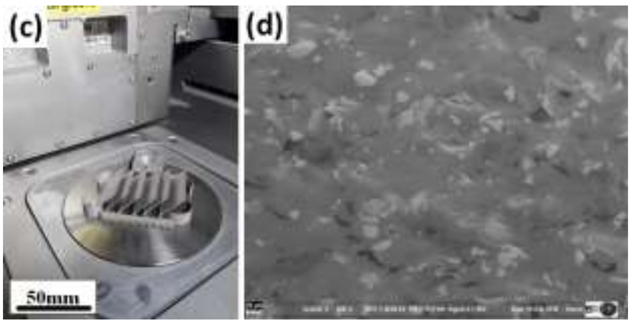

Figure 2: (c): SLM manufactured parts of ZTi-Med®,(d) microstructure via SEM of ZTi-Med®

Highest resolution 3D printing in research and industry

Alexander Legant

Nanoscribe GmbH & Co. KG, Hermann-von-Helmholtz-Platz 6, 76344 Eggenstein-Leopoldshafen, Germany

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References

[1] www.nanoscribe.com

Figures

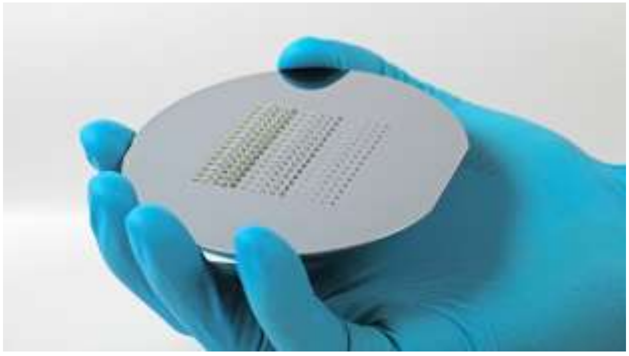

Figure 1: Batch processing of MEMS parts for batch processing on 4” wafer

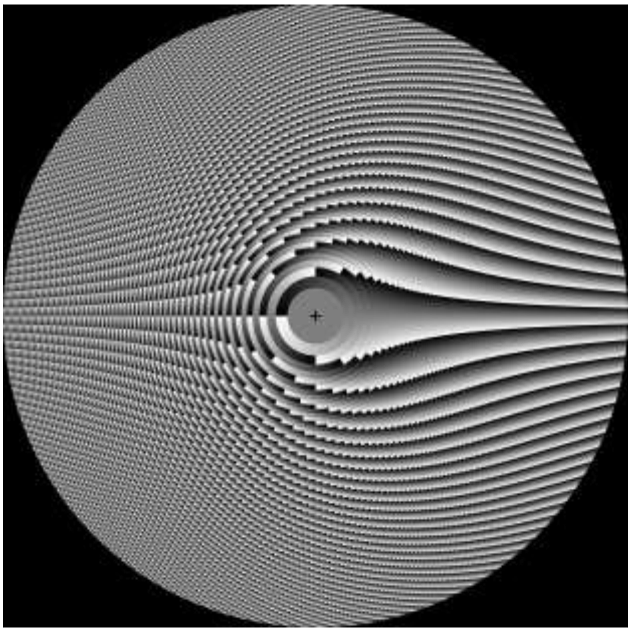

Figure 2: Diffractive Optical Element with pixel sizes down to 500 nm. Area: 2 mm x 2 mm (design Diffratec Optics OG)

Nanostructured magnetic powders produced by gas atomization

José Manuel Martín[1,2]
Kenny L. Alvarez[1,2], Nerea Burgos[1,2], Mihail Ipatov[3,4], Julián González[3]

[1]*CEIT-Basque Research and Technology Alliance (BRTA), Manuel Lardizabal 15, 20018 Donostia / San Sebastián, Spain*
[2]*Universidad de Navarra, Tecnun, Manuel Lardizabal 13, 20018 Donostia / San Sebastián, Spain*
[3]*Dept. of Materials Physics, University of the Basque Country, San Sebastián, Spain*
[4]*SGIker (Magnetic Measurements), University of the Basque Country, San Sebastián, Spain*

jmmartin@ceit.es

New compositions of Fe-Si-B-P-Nb-Cu powders were produced by gas atomization with helium [1]. The powder fraction with a particle size below 20 µm exhibited an amorphous structure (Figure 1). The $(Fe_{0.76}Si_{0.09}B_{0.10}P_{0.05})_{97.5}Nb_{2.0}Cu_{0.5}$ (at. %) alloy was annealed in the supercooled liquid region (480 °C) and at the first crystallization peak (530 °C). Annealing this alloy in the supercooled liquid region (at 480 °C) mainly produced structural relaxation, yielding a significant reduction of the coercive field (from 2.24 to 0.94 Oe) and an increment of the saturation magnetization (from 139 to 146 emu/g). Annealing at the first peak temperature (at 530 °C), produced a microstructure formed by a-Fe(Si) nanocrystals of approximately 16-17 nm in diameter, embedded homogeneously in an amorphous matrix (Figure 2). This material exhibited better soft magnetic properties than the amorphous precursor (saturation magnetization of 144 emu/g and a coercive field of 0.69 Oe in the sample annealed for 30 min). The saturation magnetization at room temperature is rather similar for the amorphous relaxed sample (annealed at 480 °C) and for the nanocrystalline alloys (annealed at 530 °C), indicating that both the crystalline and the relaxed amorphous phases have similar saturation magnetization [2]. The very low coercivity of the nanocrystalline alloy is explained by the random averaging of the magnetocrystalline anisotropy of the a-Fe(Si) nanocrystals within a larger ferromagnetic correlation exchange volume [3].

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Figures

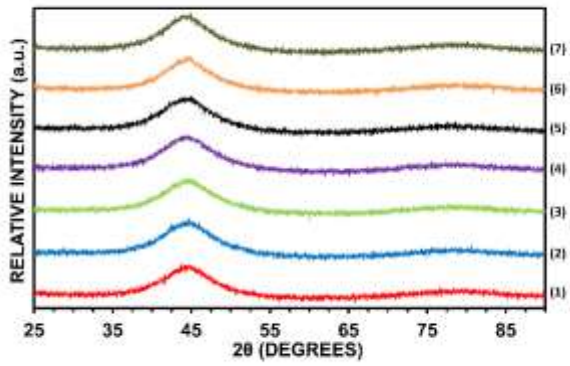

Figure 1: X-ray diffraction patterns of gas atomized powders with particle size < 20 µm of 7 different compositions in the system Fe-Si-B-P-Nb-Cu

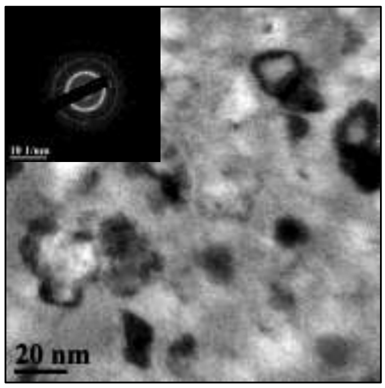

Figure 2: Bright field TEM image and SAD pattern (inset) of $(Fe_{0.76}Si_{0.09}B_{0.10}P_{0.05})_{97.5}Nb_{2.0}Cu_{0.5}$ alloy annealed at 530 °C for 30 min

New strategies for Direct Laser Writing of metallic structures

Wera Di Cianni[1,2] Michele Giocondo[1,2], Roberto Bartolino[1,2], Alberto Sanz de León[3]

[1]Dpto. Fisica, Università della Calabria, 87036 Arcavacata di Rende (CS), Italy
[2]CNR - NANOTEC Istituto di Nanotecnologia, 87036 Arcavacata di Rende (CS), Italy
[3]Dpto. Ciencia de los Materiales, I. M. y Q. I., IMEYMAT, Facultad de Ciencias, Universidad de Cádiz, Campus Río San Pedro, s/n, 11510 Puerto Real (Cádiz), Spain.

weradicianni@gmail.com
wera.dicianniscrivano@alum.uca.es

Abstract

Direct Laser Writing (DLW) of metallic structures is a promising technique for additive manufacturing of arbitrarily complex objects with nanometric resolution [1]. In the case of gold precursors (tetrachloroauric (III) acid, $HAuCl_4$) this fabrication method is triggered by the Two Photon Absorption (TPA) process [2]. The presence of a polymeric matrix (typically polyvinyl alcohol, PVA) is crucial to keep the gold nanoparticles (AuNPs) at their place, thus preventing their free diffusion. Moreover, since the writing process occurs at the interface of the matrix with the solid substrate, it is mandatory for the last to be optically accessible.

In this study, we used bio-based hydrogel matrices (isinglass, agarose gel) instead of PVA, keeping an eye open on green chemistry. Isinglass has high transparency at the used wavelength for DLW (785 nm). Influence of different substrates (e.g. silicon, glass, silica nanowires) was also tested, evaluating the feasibility of DLW on non-transparent materials. In order to achieve the steady-state ionic concentration, the hydrogel-coated substrate was bathed in an aqueous solution of $HAuCl_4$[3]. Then, different nanostructures (linear and isolated points shapes) were printed: this step is called 'seeding' because the gold precursor acts as a photoresist and the photoreduction is the photopolymerization; the objects are created only where the TPA threshold is reached. After DLW printing, a subsequent bath in deionized water removes the non-reduced gold ions, stopping the NPs growth showing that a control of AuNPs growth kinetics is possible [4]. To better monitor the growth of the AuNPs, we did a second $HAuCl_4$ bath varying two parameters (this step is called "growing"): the duration of the bath and the concentration of the aqueous solution. A control on the ionic concentration led to an important improvement of the created structures quality. This showed that a second bath in $HAuCl_4$ allows to grow the AuNPs printed controllably (Figure 1).

We conclude that the methodology herein developed achieves uniformity of the created structures rich of gold and a good compliance with the geometrical model.

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Figure

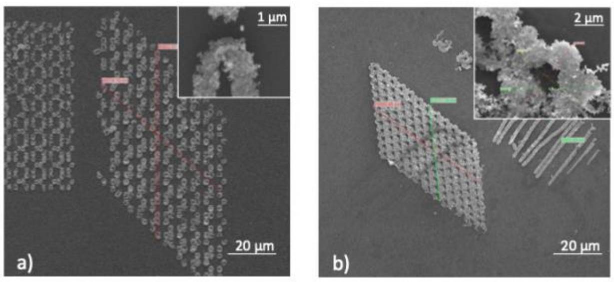

Figure 1. SEM images and their magnifications of AuNPs fabricated a) by DLW and b) after subsequent immersion in a bath of 10^{-2}M concentration $HAuCl_4$ for 24 hours.

3D-printing of drug loaded hydrogel inks – Relating rheology to printability

Oliver Etzold[a]
Robert H. Aguirresarobe[b], José M. Asua[a] and Marcelo Calderón[a,c]

(a) POLYMAT and Applied Chemistry Department, Faculty of Chemistry, University of the Basque Country UPV/EHU, Paseo Manuel de Lardizabal 3, 20018 Donostia – San Sebastián, SPAIN
(b) POLYMAT and Polymer Science and Technology Department, Faculty of Chemistry, University of the Basque Country UPV/EHU, Paseo Manuel de Lardizabal 3, 20018 Donostia – San Sebastián, SPAIN
(c) IKERBASQUE. Basque Foundation for Science, Maria Diaz de Haro 3, 48013 Bilbao, SPAIN

Oliver.Etzold@polymat.eu

For the last couple of decades, hydrogels have gained a lot of significance in pharmaceutical applications. Nowadays, myriad materials are known to form hydrogels with applications including drug and gene delivery, tissue engineering and cell therapy.[1, 2] In drug delivery, 3D printing provides spatial precision and thus potential control of the release profiles for the delivery of multiple drugs.[2, 3] The resolution in this context is a key parameter as it determines the final drug concentration. A good control over the whole process is therefore necessary and rheology appears a valuable tool to predict the material performance.

The present study investigated how a mixture of FDA-approved poly(ethylene glycol) (PEG) and carboxymethyl cellulose (CMC) is influenced by the concentration of its constituents in terms of rheological behaviour. Additionally, it was shown how the incorporation of clinically relevant amounts of drug has further influence thereon. Based upon their rheological behaviour, the printability of those mixtures by extrusion 3D-printing was assessed (*Fig. 1*). Key parameters in rheological behaviour were identified to predict the printability. Finally, this study sought to influence those key parameters due to chemical reasoning.

The authors kindly acknowledge the funding of this study by the Basque government *via* the ELKARTEK (KK-2019/00048) program.

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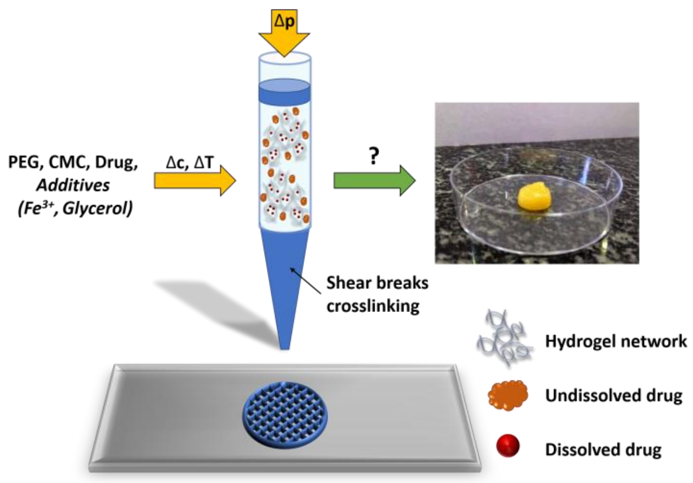

Figure 1: Schematic representation of the study. Rheological behaviour of drug-loaded CMC-PEG mixtures is screened with respect to material composition and printing conditions (*yellow arrows*). Based on those results, the printability is related to key rheological parameters (*green arrow*).

Additive micromanufacturing of metal microstructures

W. W. Koelmans
G. Ercolano, E. Hepp and T. Merle

Exaddon AG, Sägereistrasse 25, Glattbrugg, CH

wabe.koelmans@exaddon.com

The relentless drives to miniaturize components, and to customize and shorten production cycles set a welcoming stage for additive micromanufacturing (µAM) of metal microstructures. Here we present a µAM technology that is a combination of fluidic scanning probe microscopy and 3D printing [1, 2]. A plating electrolyte is locally delivered by a cantilever with a buried microchannel and a nano-nozzle, see Figure 1. The electrodeposition process enables a one-step, room temperature manufacturing method yielding a high-quality metal. Various metals like Cu, Ag, Au and Pt can be printed.

An object is built up sequentially out of 3D building blocks termed voxels. Accurate control of the air pressure used to expel the electrolyte from the nozzle enables tuning of the voxel diameter. Figure 2 exemplifies tuning using two different pressures to print a microconnector. The top and bottom parts are made at pressures of 30 and 200 mbar respectively, resulting in voxel diameters of ~3 µm and 13 µm, respectively.

Other first-of-a-kind prints with µAM include decorative microstructures, 3D wire bonds and micro-springs with horizontal plateaus. The technology presented is industrially scalable and drives additive micro-manufacturing of metals well beyond its current state.

Figures

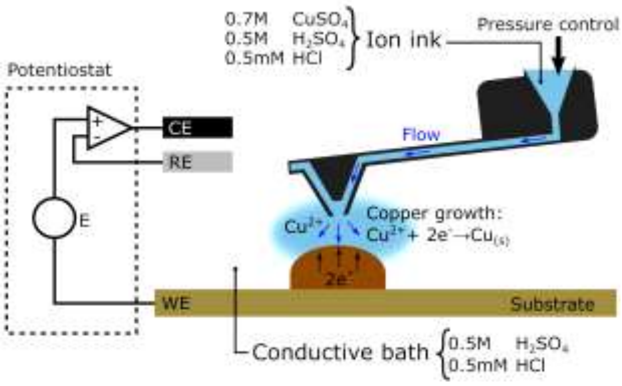

Figure 1: Schematic of the µAM technology. A plating electrolyte for copper is locally delivered to print a voxel.

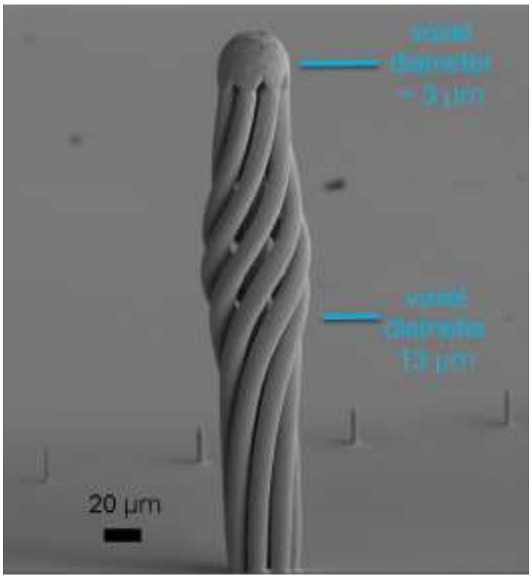

Figure 2: A copper microconnector made by µAM. The voxel diameter was chosen larger for the strands in the bottom section than for the dome of in the top section.

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Mechanical performance of bio-polyamide nanocomposites manufactured through FFF

Estefanía Rodríguez Alonso
Manuel Herrero Villar
Esteban Cañibano Álvarez
Juan Carlos Merino Senovilla

Fundación CIDAUT, Parque Tecnológico de Boecillo, 47151, Spain

estalo@cidaut.es

Additive manufacturing technologies allow creating 3D parts through layer overlap. For polymer-based materials Fused Filament Fabrication (FFF) has become the most common technology. However, it is currently difficult to predict the performance of the parts made by FFF, what limits their structural applications. This entails an important issue mainly due to the high anisotropy that layer deposition involves.

After having proving the viability of printing a nanoreinforced bio-based polyamide 11 through FFF [1] and having investigated the mechanical performance of the bio polyamides [2], in this work, a material model supported by a Finite Element Analysis tool has been developed. It attempts towards obtaining optimum parts regarding its mechanical performance with the reinforced polyamide.

The predictive model was fed by the results of a complete macro mechanical characterization carried out over printed specimens of Bio-PA11 nanocomposite at tensile, compressive and shear stress states. Experimental behaviour of the material turned out to be not only anisotropic, but also nonlinear and unsymmetrical. Apart from taking into account all these features, the model has been validated through bending tests to ensure its correlation with the experimental performance.

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Figures

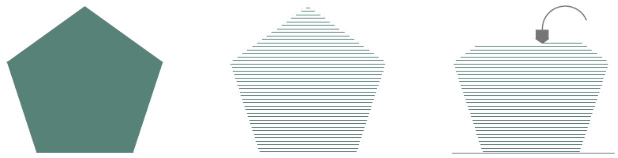

Figure 1: FFF part printing process including geometry definition, CAD slicing and material extrusion.

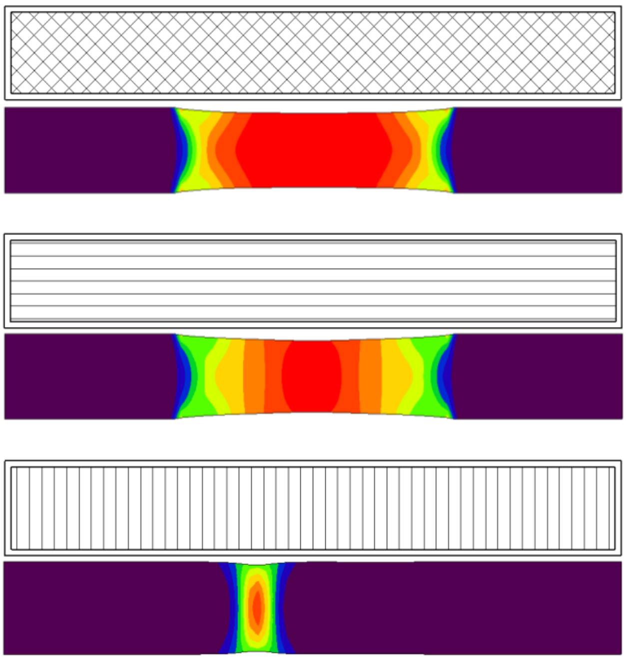

Figure 2: Strain contours obtained from tensile simulations on the three principal printing orientations (from top to bottom: flat, on-edge, upright) using the developed material model.

UV curable polyurethane acrylated resins as photoprintable biomaterial

C. Mendes-Felipe[1,2], **L. Ruiz-Rubio[1,2],** S. Lanceros[1,3], J.L. Vilas-Vilela[1,2]

[1]BCMaterials, Basque Center for Materials, Applications and Nanostructures, Leioa, Spain.
[2]Macromolecular Chemistry Group (LABQUIMAC), Leioa, Spain.
[3]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain.
*E-mail: leire.ruiz@ehu.eus

Printable flexible biomaterials are considered highly valuable materials for development of additive manufacturing based medical devices. In this context, UV radiation-curable resins have arisen as a promising source of materials. However, the commercially available inks often present biocompatibility problems or even cytotoxicity. Thus, the development of biocompatible and printable resins could be an excellent approach for advanced flexible biomedical devices. Among the possible resins used in this area, polyurethane acrylate derivatives present highly interesting properties. They are solvent-free materials, being considered green resins, and require low energy for curing compared to other conventional thermocurable products. Furthermore, photopolymerization or UV curing process is faster and obtains better patterns (for 3D printing applications)[1].

Acrylate urethanes could combine the properties of polyacrylates (good optical properties and wettability, among others) with those of polyurethanes such as high abrasion resistance, toughness and tear strength [2].

A wide range of methods exists to obtain acrylated urethane UV curable materials, being the most important the combination of a polyol with an isocyanate and the addition of an alcohol-terminated acrylate. In this study, polycaprolactone triol (PCLT), IPDI and different alcohol-terminated acrylates such as hydroxyethylacrylate (HEA) and hydroxytehylmethacrylate (HEMA) are used to obtain polyurethane acrylate (PUA) and polyurethane methacrylate (PUMA) oligomers, respectively. Fourier Transformed Infrared Spectroscopy (FTIR) is used to follow both synthesis by analysing the disappearance of the O-H (3500-3200 cm^{-1}) band and the appearance of the N-H (3390 and 1530 cm^{-1}) bands indicates the formation of the polyurethane (PU). Later, the disappearance of N=C=O band and the appearance of the C=C band where evaluated, which indicates the formation of polyurethane (meth)acrylate. Then, by adding monomers and photoinitiator, UV curable PUA resins are obtained and characterized using real time FTIR (RT-FTIR), differential scanning calorimetry (DSC) and thermogravimetric analyse (TGA), among others techniques. Finally, the influence of the acrylates on the mechanical properties of the films were also studied (Figure 1). It is important to notice that the obtained films present an excellent transparency and mechanical properties. In addition, the swelling rate observed for these materials amply their possible applications since they could be used as drug delivery systems.

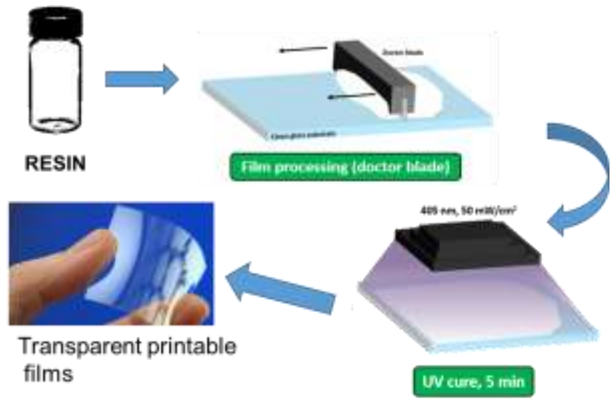

Figure 1: Scheme of the polyurethane (meth)acrylated films formation.

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3D PRINTING OF CONDUCTIVE NANOCARBON BASED COMPOSITES

David TILVE MARTINEZ
Wilfrid NERI, Philippe POULIN.

CNRS, Université de Bordeaux, Centre de Recherche Paul Pascal (CRPP), UMR 5031, 33600 Pessac, France

david.tilve@crpp.cnrs.fr
philippe.poulin@crpp.cnrs.fr

Digital Light Processing (DLP) [1] is an additive manufacturing technology, which offers new opportunities in a variety of fields. DLP is a Vat photopolymerisation process type, which manufactures objects layer upon layer by projecting 2D light patterns onto a liquid photocurable resin. This process is limited to photocurable resins that are usually insulators and transparent. Manufacturing conductive materials loaded with nanocarbon particles, including nanotubes [2], [3], [4] or graphene[5], would significantly broaden the spectrum of applications of the DLP technology as EMI shielding or stealth [6], [7]. However, several challenges are faced towards this objective. These challenges include the stabilization of nanocarbon particles into the resin, the achievement of acceptable transparency of the UV-light in order to photopolymerize the resin, and the realization of conductive materials formed by a percolation network. We will present in this work the efficient dispersions of nanoparticles and the final electrical properties of objects made by 3D printing DLP.

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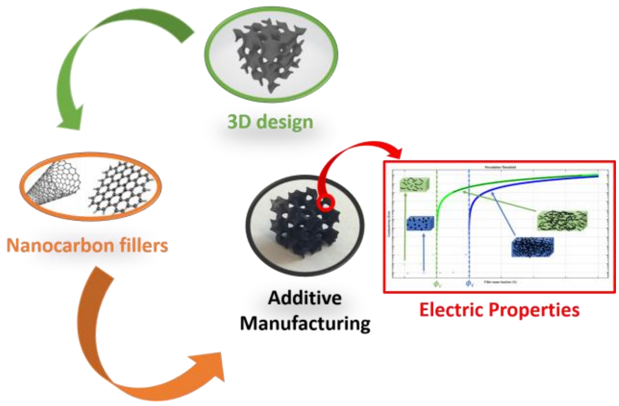

Figure 1: Schematic approach of conductor nanocarbon composites made by additive manufacturing.

The Transformation of Tasks and Skills under Additive Manufacturing: A First Look at Evidence from Job Vacancies

Ainhoa Urtasun Alonso*
Avner Ben-Ner**
Bledi Taska***
** Universidad Pública de Navarra*
***Carlson School of Management, University of Minnesota–Twin Cities*
****Burning Glass Technologies*

ainhoa.urtasun@unavarra.es

The use of additive manufacturing (AM) is rising rapidly, and as old equipment is retired, AM will likely become an important part of the economy. This general-purpose technology is poised to transform the location of production, supply chains, transportation systems, design and manufacturing processes, the look and feel of products, and organizations (Baumers and Holweg 2019, Friesike et al. 2018, Ben-Ner and Siemsen 2017). AM production processes and tasks differ substantially from those under traditional manufacturing (TM). However, there is no systematic evidence on how work differs under the two technologies. Does AM expand or restrict creativity, does it make jobs simpler or more complex, is it upskilling or deskilling, does it increase or reduce the skill gap between engineers and operators, as compared to TM? We provide the first analysis to address these questions. We focus on all 1,577 manufacturing establishments that sought to hire both AM and TM workers – to control for unobservable heterogeneity – between January 2014 and December 2019. Within-plant and within-occupation comparisons reveal that AM postings reflect considerably more complexity and require substantially more cognitive, social and advanced technical skills than TM postings. Thus, at this time, AM represents an upskilling technological change, in contrast with recent skill-biased technological changes that had contributed to rising inequality. This transformation of tasks and skills may have favorable effects on future worker well-being, wage levels and inequality.The demand for AM employees, while still very low, is growing at a fast pace. Figure 1 illustrates the growth in the number of AM and TM job postings for core manufacturing occupations (engineers, technicians and operators) in the US from 2014 to 2019.

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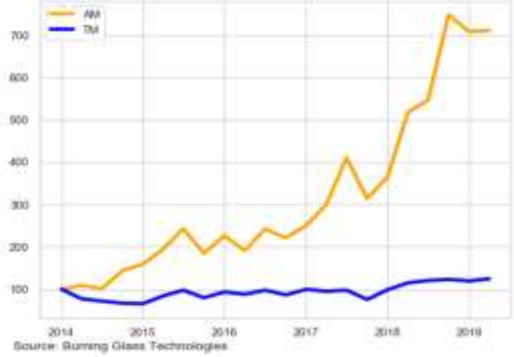

Figure 1: Evolution of Additive Manufacturing and Traditional Manufacturing Job Vacancies

3D printing of liquid silicone rubber composites via a modified Direct Ink Writing (DIW) method

Jordy Guadalupe
R. Verdejo, M. Hoyos

Institute of Polymer Science and Technology, ICTP-CSIC, Juan de la Cierva, 3, 28006 Madrid, Spain

jguadalupe@ictp.csic.es

Silicone rubber has widely been used because of its outstanding properties such as UV stability, excellent ageing properties, high chemical resistance, transparency, gas permeability, low compression set and stable mechanical properties over a wide temperature range, from -40 °C to 200 °C. However, silicone rubber manufacturing typically involves moulding processes, which limit the complexity of produced objects, as well as substantial human labour. For these reasons, additive manufacturing or 3D printing has attracted the attention of not only the scientific community [1][2] but also of the industry. In this work, we study the cure parameters of a liquid silicone rubber to be directly used in a non-commercial 3D printer via a modified Direct Ink Writing (DIW) method. Particularly, we have studied the curing kinetics, dispersions stability, and rheological properties of silicone composites to determine their effect on both printing process parameters and printed part properties. For instance, we founded that a volume flow dosing of 0,406 ml/min of the material was adequate for the printing process of a 5A type tensile specimen. We also determinate that the optimum printing temperature of the material was 70 ° C, since the sample retained the shape during the printing process and presented a good adhesion between the different layers. On the other hand, the kinetics of the silicone cross-linking process was determined by different techniques, finding activation energy of the order of 70-90 KJ/mol.

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Figures

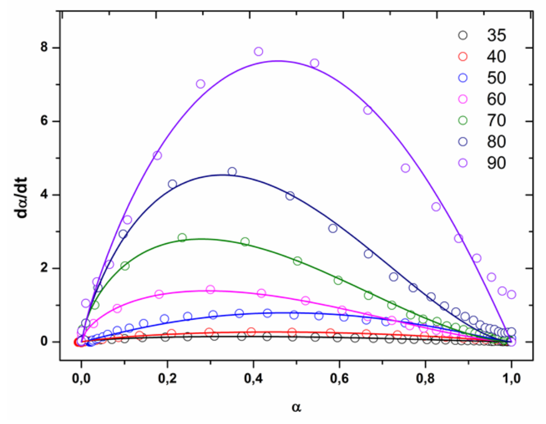

Figure 1: Rheological study on the cure kinetics of a two- part liquid silicone rubber.

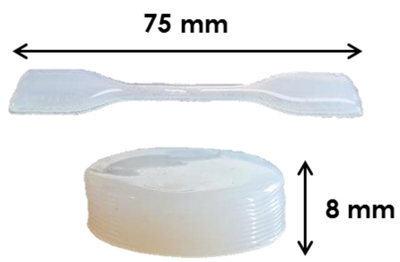

Figure 2: 3D printed samples using DIW additive manufacturing method.

Direct Ink Writing of Lignin-Graphene Oxide Ink for 3D Carbon Material Preparation

Wilfrid Neri
Julien Roman, Vanessa Fiero, Alain Celzard, Ahmed Bentaleb, Isabelle Ly, Jing Zhong, Alain Derré, and Philippe Poulin.

CNRS, Université de Bordeaux, Centre de Recherche Paul Pascal (CRPP), UMR 5031, 33600 Pessac, France

julien.roman@crpp.cnrs.fr
philippe.poulin@crpp.cnrs.fr

Direct Ink Writing (DIW) describes a fabrication method that employs a computer translation stage and ink-deposition nozzle to create 3D materials with controlled architecture and composition [1]. Colloidal gels are excellent candidate materials for DIW of complex 3D structures. Their rheological properties can be tailored to facilitate the flow through nozzle and produce patterned filaments that maintain their shape. Implementing 3D printing technologies such as DIW to process carbon materials is particularly appealing [2]. Unfortunately, carbon materials, unlike polymers and metals, cannot be easily solubilized for processed. DIW of viscoelastic graphene oxide (GO) ink successfully leads to 3D-printed carbonized materials. However, this approach has allowed for the realization of highly porous and mechanically weak graphene aerogels [3]. Our approach involves making denser 3D structures based on printed mixtures of GO and lignin, an abundant bio-derived precursor with a high carbon content [ref].

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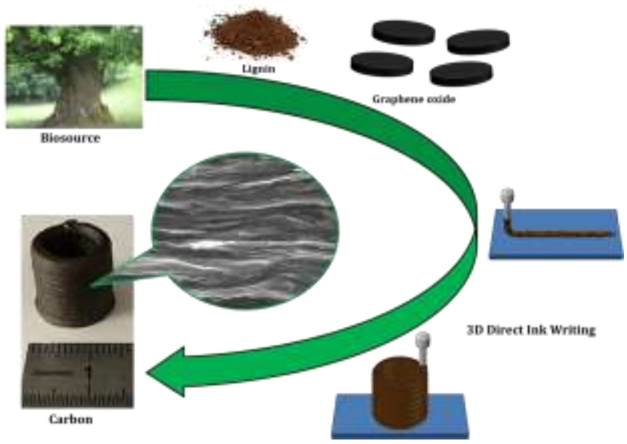

Figure 1: Schematic illustration of the fabrication strategy for 3D Printed Carbon materials.

Extrusion-based 3D printed atenolol tablets with hydroxyethylcellulose hydrogels

S. Ruiz-Alonso
M. Lafuente-Merchan, A. Espona-Noguera, L. Saenz del Burgo, JL. Pedraz

NanoBioCel Group, Laboratory of Pharmaceutics, School of Pharmacy, University of the Basque Country (UPV/EHU), Vitoria-Gasteiz, Spain

chuenesandra@hotmail.com

3D printing is an emerging technology that is progressively gaining the attention of the pharmaceutical industry [1]. One of the greatest challenges of using 3D printing for making pharmaceutical formulations is the election of the material to be used as ink [2]. Thus, the purpose of this study was to determine the adequacy of using hydroxyethylcellulose (HEC) as excipient and its capacity of incorporating the Active Pharmaceutical Ingredient (API), atenolol, for 3D printing. In this study, HEC hydrogels were prepared at different concentrations. The obtained inks were rheologically characterized and their printing properties determined. Then, the structure and morphology of the printed 3D-tablets were studied. The ink that showed the best properties was selected for incorporating the API. Then, the previously mentioned printability and rheological characteristics were studied again for this new atenolol-containing ink. The experimental results demonstrated that inks with HEC concentrations between 10% and 20% (w/v) had similar rheological and printable properties (Figure 1A). Thus, the HEC 10% ink was selected. It was proved that the incorporation of the API into this hydrogel did not modified neither the rheological profile nor the printing properties of the ink (Figure 1B). Importantly, the printed 3D-tablets replicated the shape and size of the digital design (Figure 2). In conclusion, the HEC 10% hydrogel is the ink more suitable for being used as 3D-ink as it presents good printing and rheological properties while containing the lowest quantity of excipient. Once the API was incorporated, the 3D-printed tablets presented proper morphological characteristics, which makes us think that this excipient could be a good candidate for 3D printing purposes in the development of new advanced pharmaceutical systems.

Acknowledgements: authors thank the support to research on 3D-printing from the Basque Country Government (Medprint project. Elkartek KK-2019/00048) and the ICTS "NANBIOSIS", more specifically by the Drug Formulation Unit (U10) of the CIBER-BBN.

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Figures

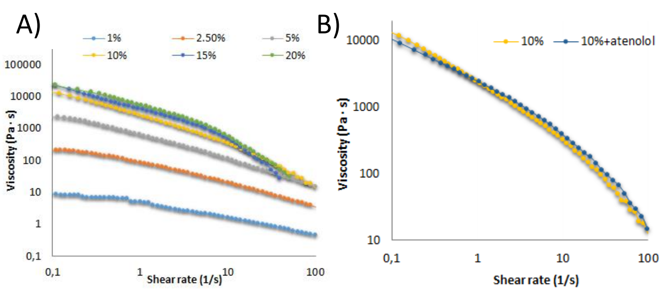

Figure 1: Viscosity measurements of A) HEC inks; B) Atenolol containing HEC ink.

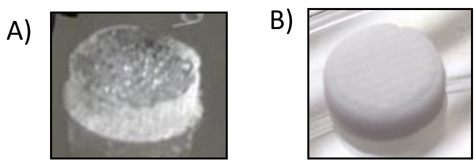

Figure 2: 3D-printed tables using A) HEC inks; B) Atenolol containing HEC ink.

IKUR STRATEGY AT A GLANCE

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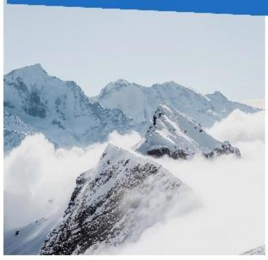
+ Info: ikur@euskampus.eu

1 What it is



IKUR 2030 is the Strategy to position the Basque Country as a scientific pole of international reference…

… with opportunities for industrial, business and institutional development

2 Its objectives

- Development of Advanced Capabilities
- "Tractor effect" of Research in the Basque Country
- Reference in Europe
- Economic and Social Impact

3 Flagship Areas

- Neurobiosciences
- Quantum Technologies (QT)
- NeutriOnics

High Performance Computing & Artificial Intelligence (HPC-AI)

4 Expected impact

Research personnel	+400
Publications	+4.000
EPO Patents	+30
Spin offs	+20
Turnover	+350 M€
Employment	+3.200

5 Governance

ikerbasque – Basque Foundation for Science
- Recruitment and attraction of research personnel
- Management of IKUR funds

EUSKO JAURLARITZA – GOBIERNO VASCO
HEZKUNTZA SAILA – DEPARTAMENTO DE EDUCACIÓN

Fundación Biofísica Bizkaia / Biofisika Bizkaia Fundazioa – Neurobiosciences

DIPC – QT + HPC-AI

MPC Materials Physics Center – NeutrIOnics

Scientific Direction of IKUR's Flagship Areas

euskampus Fundazioa
- Monitoring and evaluation the impact of the IKUR Strategy