7TH YOUNG POLYMER SCIENTISTS CONFERENCE AND SHORT COURSE

PROGRAM AND ABSTRACTS

Lodz University of Technology

Faculty of Chemistry

Department of Molecular Physics

27-28 September 2021, Lodz, Poland, online

7thYoung Polymer Scientists Conference & Short Course, 27-28. 09. 2021, Lodz, Poland

Scientificprogram of tutorial lectures (**T**) and young scientists'short communications (**Y**)

Monday, September 27th, webinarium		
8:40 – 9:00		Opening Ceremony
Chairperson: Jacek Ulański	9:00 – 9:40	(T1)**Andrzej Gałęski**, Centre of Molecular and Macromolecular Studies, Polish Academy of Sciences, Lodz, Poland ***Processing induced strengthening of polymers***
	9:40 – 10:20	(T2)**Krzysztof Matyjaszewski**, Carnegie Mellon University, Center for Macromolecular Engineering, Pittsburgh, USA, & Lodz University of Technology, Department of Molecular Physics, Lodz, Poland ***Nanostructured Polymers and Nanocomposites by ATRP***
	10:20 – 10:35	**(Y1) Helen Pfukwa**, Department of Chemistry and Polymer Science, Stellenbosch University, Stellenbosch, South Africa ***Bio-based aldehyde-functionalised polymers by reverse iodine transfer polymerization***
	10:35 – 10:50	**(Y2)Mahrukh Sadaf**,Department of Enterprise Engineering "Mario Lucertini", and INSTM RU Roma-Tor Vergata,University of Rome "Tor Vergata", Rome, Italy ***Properties and processing of multi-component thermoplastic binder systems for extrusion-based additive manufacturing***
10:50 – 11:30		COFFEE BREAK
Aleksandra Wypych-Puszkarz	11:30 – 12:10	(T3)**Andrzej Rybak**,ABB Corporate Technology Center, Krakow, Poland ***Influence of polymer processing on thermal conductivity of nanocomposites***
	12:10 – 12:50	(T4)**Francesca Nanni**, University of Rome Tor Vergata, Italy ***Present trend of polymers and composites application in the aerospace sector***
	12:50 – 13:05	**(Y3)Piotr Węglarski**, Department of Molecular Physics, Lodz University of Technology, Lodz, and Corning Optical Communications Sp. z o.o., Strykow, Poland ***Stripping the primary coating layer from the fiber optic surface***
13:05 – 14:15		LUNCH BREAK
Lidia Okrasa	14:15 – 14:55	(T5)**Rebeca Hernandez**, Institute of Polymer Science and Technology (ICTP-CSIC), Madrid, Spain ***Polymer hydrogels and their composites with nanostructured particles: from preparation to advanced applications***
	14:55 – 15:35	(T6)**Beata Łuszczyńska**, Department of Molecular Physics, Lodz University of Technology, Poland ***Organic photodetectors for NIR biological tissue window***
	15:35 – 15:50	**(Y4)Ulrike Staudinger**, Leibniz-InstitutfürPolymerforschung, Dresden, Germany ***Dispersion and electrical percolation of shortened carbon nanotubes in styrene-butadiene based block copolymers***
	15:50 – 16:05	**(Y5)Busra Findik**, Ingénierie des MatériauxPolymères, Université Claude Bernard Lyon, Lyon, France ***Synthesis of new nanocomposites based on magnesium and silicon by the combination of in situ sol-gel chemistry and reactive extrusion***
	16:05 – 16:20	**(Y6)Jakub Szewczyk**, NanoBioMedical Centre, Adam Mickiewicz University, Poznan, Poland ***A novel, ultrathin 2D-like polydopamine membranes from the air/water interphase – tuning polymerization process towards better understanding of their nanostructure***
16:20 – 16:40		COFFEE BREAK
16:40 – 18:40		**Poster session I**
19:00 – 21:00		**Poster session II**

Chair	Time	Tuesday, September 28th, webinarium
Marcin Kozanecki	8:30 – 9:10	(T7)**Brigitte Voit**, Leibniz-InstitutfürPolymerforschung, Dresden, Germany ***Synthesis of functional polymeric materials for optoelectronic applications***
	9:10 – 9:50	(T8)**Jiri Pfleger**,Institute of Macromolecular Chemistry, Czech Academy of Sciences,Prague, Czech Republic ***Application of polymers in solution processable organic electronic devices.***
	9:50 – 10:05	**(Y7)Angelika Wrzesińska**, Department of Molecular Physics, Lodz University of Technology, Lodz, Poland ***Investigation of molecular dynamics of poly(dimethylsiloxane) cross-linked by metal-ligand complexes by broadband dielectric spectroscopy***
	10:05 – 10:20	**(Y8)Mario Iván Peñas**, Institute of Polymer Science and Technology (ICTP-CSIC), Madrid, and University of the Basque Country, Donostia-San Sebastián, Spain ***Nanostructured thin films obtained by dip-coating poly(butylene succinate), poly(ε-caprolactone) and their copolyesters (PBS-ran-PCL)***
10:20 – 11:00		COFFEE BREAK
Beata Łuszczyńska	11:00 – 11:40	(T9)**Paul Blom**, Max Planck Institute for Polymer Research, Mainz, Germany ***Charge transport in organic semiconductors***
	11:40 – 12:20	(T10)**Yingping Zou**, Central South University, Changsha, China ***Organic polymer optoelectronic materials***
	12:20 – 12:35	**(Y9)Krzysztof Jerczyński**,Institute of Polymer and Dye Technology, Lodz University of Technology, Lodz, Poland ***Molecular brushes used as templates for titanium dioxide nanoparticles synthesis***
	12:35 – 12:50	**(Y10)Andrzej Świeży**, Faculty of Chemical Engineering and Technology, Cracow University of Technology and Photo HiTech Ltd, Cracow, Poland ***One-component cationic photoinitiators for preparation semiconductor nanoparticles filled photopolymer composites***
12:50 – 13:50		LUNCH BREAK
Gabriela Wiosna-Sałyga	13:50 – 14:30	(T11)**Stefan Jurga**, NanoBioMedical Centre, Adam Mickiewicz University, Poznan, Poland ***Nanomaterials for biomedicine***
	14:30 – 15:10	(T12)**Tsuneo Hagiwara**, Yokohama National University, Yokohama, Japan ***Photocurable resin for 3D Printing***
	15:10 – 15:25	**(Y11)Sonal Gupta**,Institute of Macromolecular Chemistry, Czech Academy of Sciences,Prague, Czech Republic ***Enhanced antibacterial activity of polypyrrole with tunable conductivity, morphology and capacitance by acriflavine hydrochloride***
	15:25 – 15:40	**(Y12)Tatiana Statsenko**, ITMO University and N.E. Bauman Moscow State Technical University, Moscow, Russia Federation ***Optically active nanocolloidal ink for 3D printing***
15:40 – 16:00		COFFEE BREAK
Piotr Polanowski	16:00 – 16:40	(T13)**Jean-Francois Gérard**, National Institute of Applied Sciences of Lyon-INSA, France ***Building of polymer networks: focus on gelation phenomenon***
	16:40 – 17:20	(T14)**Krzysztof Hałagan**, Department of Molecular Physics, Lodz University of Technology, Lodz, Poland ***Computer simulations of non-equilibrium phenomena and complex polymer systems with cooperative dynamics***
	17:20 – 17:35	**(Y13)Ron Dockhorn**, Institute Theory of Polymers, Leibniz Institute of Polymer Research, Dresden, Germany ***Polymer architectures by chain walking catalysis - theory, simulations, and experiments***
17:35 – 18:00		Concluding remarks
18:00 – 20:00		**Poster session III**

Photocurable Resin for 3D Printing

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1. Introduction:

With the invention of the stereolithography method (SLA) in the 1980s, various three-dimensional Additive Manufacturing (AM) methodshave been invented and put into industrial use.Today, each fundamental patents' right has been expired after more than 20 years have passed and big turning point has arrived. Inexpensive Material Extrusion (MEX) type 3D Printer becomes very popular for engineer and hobbyist, and an opportunity for "New Manufacturing Era" has arrived.

Today, in order to promote Digital Transformation (DX) manufacturing, 3D printingisconsidered to be important and convenient with great expectations.

2. 3D printing:

The word "3D printer" is well known to elementary school students.3D printing is based on 3DCAD data, liquid photocurable resin, thermoplastic resin, plastic powder, metal powder, gypsum powder, sand, etc. are used, and laser beam, electron beam, melt-extruded InkJet, etc. are used to accumulatethem layer by layer, which is defined as Additive Manufacturing (AM).The device is often referred to as a "3D printer" in simple terms and the technology is called "3D Printing". Table 1 summarizes the 3D Printing technology classified by ASTM.

Table-1: Classified 3D printing methods

AM Process	Common name	Materials	Tool	Characteristics	Usage
Vat Photo polymerization	SLA	Photocurable resin	LASER, LED	Accuracy、Detaile d Large size、	Prototypes
Powder Bed Fusion	SLS, SLM, EBM HSS	PA12powder、 Metal powder	LASER, Electron Beam	Products (PA, Metal)	Prototypes Products
Material Extrusion	FDM, FFF	ABS, PC Wire etc,	Heating	Easy, ABS ～ PEEK	Verification, High performance prototypes
Binder Jetting	Ink Jet, Z-Printer	Plaster、Sand Aqua binder	Ink Jet	High Speed, Full color	Figure Natural sand
Material Jetting	PolyJet, MJM	Photocurable resin	Ink Jet	Relatively easy Expression	Verification Expression
Sheet lamination	Sheet lamination, LOM	Paper, Plastic sheet	LASER, Cutter knife	Simple Full color	Stereo map
Directed Energy Deposition	LENS, DED	Metal powder	LASER	Metal	Metal parts
Hybrid		Metal powder Thermoplastic pellet	LASER + CNC Heat + CNC	Accuracy, Surface quality	Metal parts, Mold Large plastic parts

industries, but from the viewpoint of the materials we get on a daily basis, each method is not yet in a sufficient performance. At present, users devise and use limited materials properly.

I have been engaged in 3D Printing field developing photocurable resin for VPP from 1991, in this lecture I introduce current status of 3D Printing and typical application of the VPP 3D printing.

2. Vat Photo Polymerization (VPP; stereolithography; SLA) method and its photocurable resin

The VPP method is classified two types, one is "free liquid level type" irradiating 355nm laser beam from top area (Fig.1), and the other is "regulated liquid level method" irradiating laser beam (405nm) from bottom area (Fig.2) or irradiating UV/LED light by using DLP from bottom area (Fig. 3). Most of the low-price VPP equipment adopts this method because the system construction is simple.

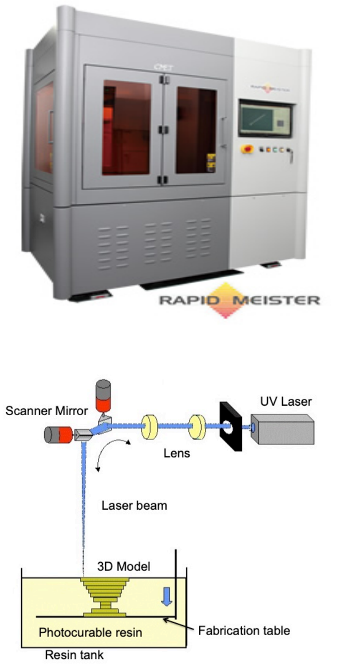

Fig-1 Large size laser VPP system

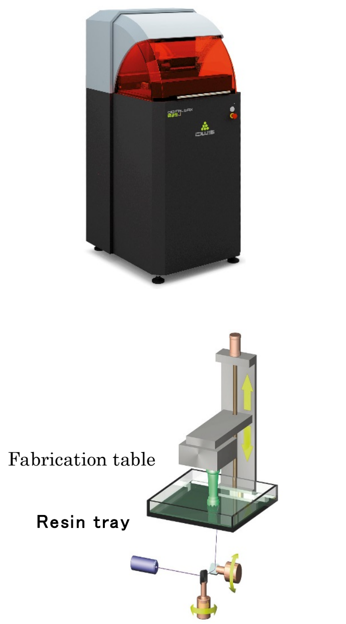

Fig-2 Regulated liquid type laser VPP system

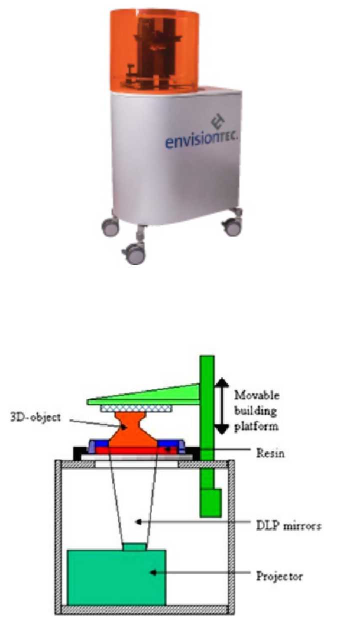

Fig-3 DLP type VPP system

The large-scale laser-type (free liquid level type) VPP systems is shown in Fig-1, in the resin tank it is commonly using a hybrid composition having epoxy and acrylate compounds. On the other hand, "regulated liquid level method" type shown Fig-2 and Fig-3 use (urethane) acrylate-based photocurable resins. The (urethane) acrylate-based photocurable resin is suitable for an inexpensive small-sized device because it has abundant compounds and cures with low energy as compared with the epoxy-acrylate based hybrid resin.

3. Application of 3D printing using photocurable resin

The application of the VPP method is first of all, a man-machine interface for obtaining an industrial product from CAD data to a three-dimensional model, and tools and various simulations for efficient product development. It is to be used for industrial production.

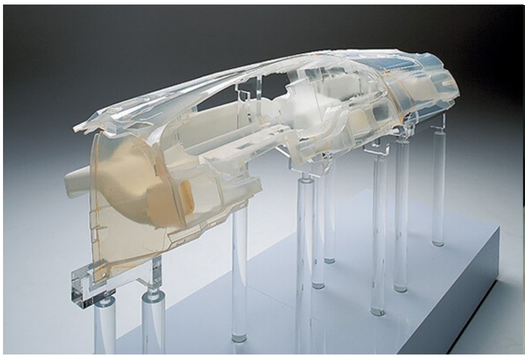

Fig-4: Prototype model

Fig-5: Functional test model

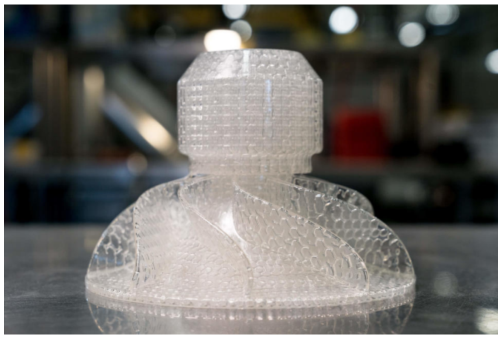

Fig-6: Casting model for burn-out

There is a big trend to make final products with 3D printers. However, the physical properties of the VPP method are not yet sufficient, there are currently only a limited number of examples of direct use for final products of industrial usage.

A typical example is the shell of a hearing aid with a DLP machine. Hearing aids have different ear shapes for each individual, so they are suitable for 3D printing based on CAD data in order to adapt them to each other.

In addition, jewelry applications for shaped objects have come to play a major role. 3D printing has made a breakthrough in jewelry production, which was mostly traditional manual work.

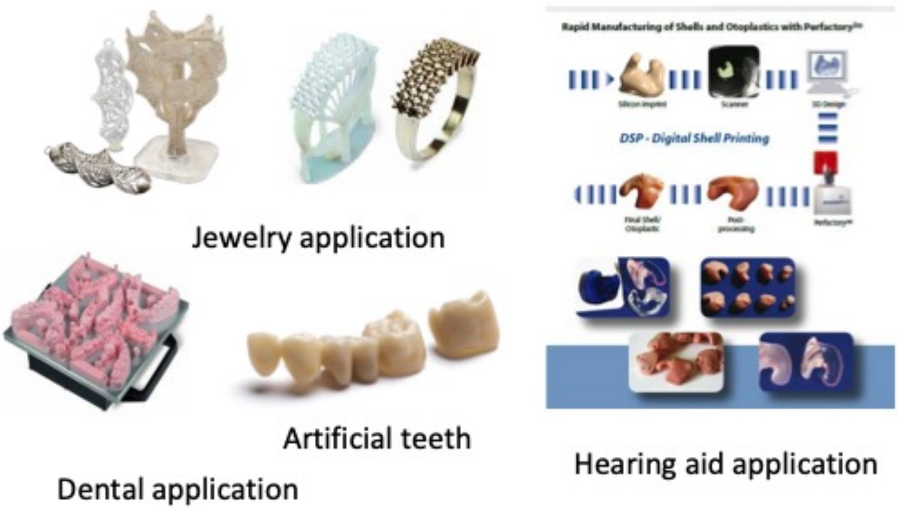

Fig-7: Typical application for jewelry, dental and hearing aid.

And the application of dentistry is advancing.Dentistry is the same size as the jewelry field, and many of the techniques cultivated in jewelry can be used.After outputting the data obtained from an intraoral scanner to STL format, by VPP systems (i) a wax pattern for casting, (ii) a casting pattern called a denture for castingand (iii) a tooth profile called a plaster model are created. It is shaped and used for dental purposes. In addition, the development of materials for directly modeling artificial teeth and orthodontic jigs (aligners) ideal for patients using data output by a three-dimensional intraoral scanner is also in progress.

In March 2015, "Carbon 3D, Inc." (Now Carbon, Inc.) announced a high-speed laminated modeling process that uses a "Continuous liquid Interface Production (CLIP)"by continuous lifting process using DLP with a big topic. After the announcement of the CLIP method, many DLP equipment company developed same kind of the high speed systems. And the VPP method is drawing attention again. These are those that irradiate light in synchronization with continuous pulling, and although there are some restrictions on the shape, it is possible to make model at a high speed several times higher than the conventional method, so attention is paid from various fields. Carbon,Inc., together with Adidas, developed the application to the bottom part of sports shoes and promoted the practical application to the final product. “Figure4” system of 3D Systems announces several resins that provide high-speed shaped objects with good physical properties that can withstand long-term changes of 5 years or more for use in final products.

Fig-8: Foot wear application

In response to the trend to manufacture final products with high-speed DLP machines, large European chemical companies are joining the material development one after another. BASF, Henkel and EVONIK are entering the market with their own photocurable resins.

4. New Application of VPP method using photocurable resin:

Lithoz, a venture company of the TU Wien in Austria, is promoting ceramic 3D printing with a bottom-irradiatingsystemusing DLP. On the other hand aSystem called “CeraMaker” from 3D Ceram-Shinto of France has been launched as a system to obtain a ceramic-containing model by using a bred paste-like resincontaining a high concentration of ceramic, and irradiating it with an 355nm ultraviolet laser. It has been developed into three-dimensional fabricating of various ceramics.

Adomatec of the Netherlands has put into a market with a device that applies a ceramic-containing photocurable resin on a PET film and irradiates it with light from the bottom surface using DLP.

The ceramic 3D printing using photocurable resin is becoming active, and it is considered to be a big market.

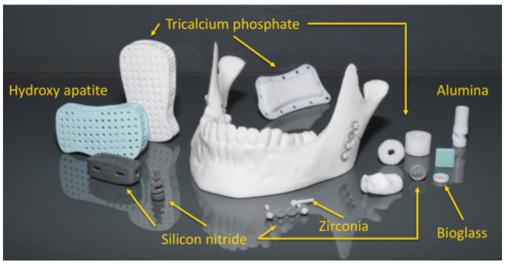

Fig-9: Ceramic application by Lithoz

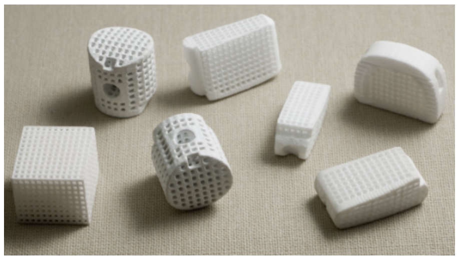

Fig-10: Hydroxyl apatite scaffold by 3D Ceram-Shinto

Fig-11: PTFE model by 3M

The Adomateccompany enables metal fabrication by modeling using metal fine particles instead of ceramics.3M is proposing the modeling of polytetrafluoroethylene (PTFE)using photocurable resin containing the powder.

5. Summary:

3D printing has the longest history, starting from the VPP method. The shaped objects obtained by this method cover a wide range from relatively large to small ones, and have high precision and high definition, and have made a great contribution to manufacturing in the industrial world. The physical properties of photocured products (modeled products) have been developed withthe aim of ABS performance from the beginning, but have not yet reached that performance.It is being recognized that 3D printing will bring about a change in manufacturing, and the material development is attracting attention again.In particular, the development of materials for bottom-illuminated high-speed DLP machines is fierce, and it will be fully utilized as a final product in the very near future.It is expected that materials that can be produced will be developed. As a result, it is estimated that the VPP method, which specializes in high-speed, highly precise, and high-definition shaped objects, will contribute more and more to manufacturing.

[1] Terry Wohlers; "Wohlers Report 2021", (Wohlers Associates, Fort Collins, Colorado, USA
[2] Tsuneo Hagiwara; " Engineering Materials", vol. 64, No.5(2016)pp18-24, and vol. 68, No.7(2020)p23-32.
Tsuneo Hagiwara; http://www.thagiwara.jp
[3] Formlabs; https://formlabs.com
[4] DWS; https://www.dwssystems.com
[5] Cubicure; https://www.cubicure.com
[6] EnvisionTEC; https://envisiontec.com
[7] Carbon; https://www.carbon3d.com
[8] Photocentric; https://photocentricgroup.us
[9] 3DSystems Figure 4; https://www.3dsystems.com/materials/figure-4-rigid-white
[10] Carbon; https://www.carbon3d.com/white-papers/carbon-lattice-innovation-the-adidas-stor
[11] 3D Ceram-Shinto; https://3dceram.com/en/
[12] Lithoz; https://www.lithoz.com/en
[13] 3M; https://www.3m.com/3M/en_US/design-and-specialty-materials-us/3d-printing/