Optical 3D Micro- and Nano-formation of Bioplastics

SUMMARY

The present technology allows printing complex 3D micro- and nano-structures from environmentally friendly plant-derived material – acrylated epoxidized soybean oil. Non-toxicity and high biodegradability enable application in biomedicine, micro-optics and nanophotonics.

BACKGROUND

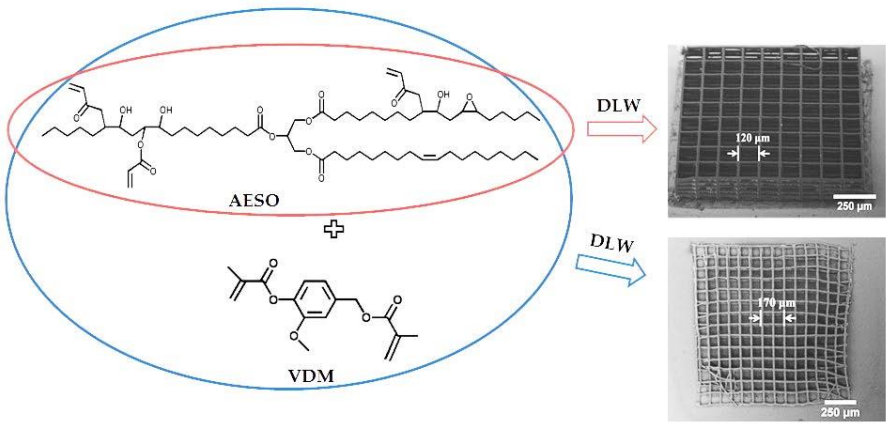
3D printing is a simple, low-cost and flexible additive manufacturing technique to create complex structures that cannot be cut, assembled or carved. It is especially useful in rapid fabrication of micro- and nano-structures to be used in health area, nanoelectronics, nanophotonics, etc. The most popular materials for optical 3D printing – epoxy and acrylic resins, have good mechanical properties, but are derived from petroleum, may have toxic ingredients, have low biodegradability, and therefore limited scale of applicability.

Currently, soybean oil is one of the most promising materials to replace petroleum-derived resins. Acrylated epoxidized soybean oil (AESO) can be polymerized by ultraviolet / visible light using appropriate photoinitiators and cross-linking agents, however the majority of these stiffening compounds are petroleum-derived and are harmful to health.

TECHNOLOGY

The present technology is based on polymerization of plant-derived AESO resins using ultrashort laser pulses. We use pure AESO resin or AESO mixed with a photoinitiator (vanillin dimethacrylate (VDM) or vanillin diacrylate) to obtain mechanical and thermal properties that are sufficient for practical application in 3D optical printing.

Using Direct Laser Writing (DLW) 3D lithography technique, photo-crosslinking can be achieved by tightly focusing ultrashort laser pulses into AESO resin, thus initiating a polymerization reaction. Selectively exposing material to laser radiation allows creating fully 3D structures with submicrometer spatial resolution. The smallest achieved spatial features are 1 μm with a throughput of 6900 voxels per second. Since the 3D cross-linking of the plant-derived materials is initiated using ultrafast laser induced multiphoton absorption and avalanche ionization, it does not require the usage of any photoinitiator, thus enabling green 3D micro-printing [1].



TECHNOLOGY READINESS LEVEL

TRL 4 – technology validated in the laboratory.

INTELLECTUAL PROPERTY

Invented in cooperation between Vilnius University and Kaunas University of Technology by: Miglė Lebedevaitė, Jolita Ostrauskaitė, Edvinas Skliutas, Mangirdas Malinauskas.

PUBLICATIONS

[1] M. Lebedevaite, J. Ostrauskaite, E. Skliutas, M. Malinauskas. Photoinitiator Free Resins Composed of Plant-Derived Monomers for the Optical μ-3D Printing of Thermosets. Polymers 2019, 11(1), 116. https://doi.org/10.3390/polym11010116

BENEFITS

- Bio-friendly: 3D micro-printing from plant-derived, non-toxic and highly biodegradable material.
- DLW technique does not require the usage of any photoinitiators.
- Mechanical and thermal properties are sufficient for practical application for table-top and industrial grade optical 3D printing.
- The smallest spatial features are 1 μm with a throughput of 6900 voxels per second.
- Non-toxicity allows application in biomedicine.
- Avoidance of photoinitiators reduces auto-fluorescence while performing microscopy.

APPLICATION

The present technology can be used in various applications:

- Printing 3D cell-growth scaffolds;
- Microscopy (*in vitro* or *in vivo*);
- Biomedicine;
- Micro-optics;
- Nanophotonics.

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