An entire world between black and white: Multi-material 3D printing with grayscale lithography

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Modern devices, such as medical prostheses and data storage systems, often require the integration of multiple material properties. Traditionally, fabricating such components involves combining separately manufactured single-property parts using various engineering and manufacturing techniques. As a result, achieving true multi-material printing from a single vat has become a central focus in light-based 3D printing.
Techniques such as greyscale lithography (varying light intensity) and multi-wavelength printing (using different light colors) have enabled the tuning of material stiffness within a single resin by adjusting crosslinking density through controlled monomer conversion. However, these property differences tend to diminish over time due to post-curing from residual unreacted monomers, and the range of achievable material properties has largely been limited to soft versus stiff.
This talk presents advancements in greyscale lithography that extend beyond current limitations. It will highlight the fabrication of microscale objects with finely tunable mechanical properties and the integration of both degradable and non-degradable regions within a single 3D-printed structure.
Additionally, new strategies for one-photon vat photopolymerization enabling multi-material printing of macroscopic objects will be discussed. A key innovation is the effective trapping of crystallinity in photopolymers, allowing for precise control of transparency and thermomechanical behavior. This is achieved through adjustments in printing temperature or light intensity, introducing new capabilities for tailoring material properties during the printing process. These developments mark a significant step toward versatile, functionally complex 3D-printed components from a single resin system.



Dr Katharina Ehrmann is Elise-Richter fellow and team lead of the Additive Manufacturing Team at the Institute of Applied Synthetic Chemistry, TU Wien, working on broadening the processing window of and rethinking the chemistry behind light-based additive manufacturing of polymers to obtain high-performance parts with functionality. She studied Chemistry at the University of Innsbruck (Austria) and the University of Edinburgh (UK). During her PhD in the group of Prof Robert Liska at TU Wien (Austria) Katharina developed self-reinforcing thermoplastic polyurethanes for tissue engineering applications. She then became a postdoctoral research fellow at the Queensland University of Technology (QUT, Australia) in 2021, where she worked on wavelength-resolved photopolymer-networks in the group of Prof Christopher Barner-Kowollik and has remained a visiting research fellow at QUT since her return to TU Wien in 2023. She is also a member of the International Younger Chemists Network (IUPAC) and has received several prizes and fellowships such as the Dr. Ernst Fehrer Prize, Christiana Hoerbiger Prize for young researcher mobility, the FFG Female Innovator Fellowship and the CAS Future Leaders fellowship. Her work on multi-material printing has been highlighted in Emerging Investigator Series of the renowned journals Angewandte Chemie Int. Ed. and Materials Horizon.