Two-photon microfabrication of structures containing the biopolymer Chitosan

Outline

Two-photon polymerization
Sample preparation
Experimental setup
Results on the fabrication of the microstructures
Conclusion
Two-photon polymerization

\( \text{2PA: simultaneous absorption of two photons far from a material's linear absorption region.} \)

\[ R_{2\text{PA}} \propto I^2 \]

The absorption is confined to the focal volume.

High spatial resolution
Microstructures fabricated by two-photon polymerization
Applications of two-photon polymerization

Optics and Photonics
Doping microstructures with organic molecules and metals

- fluorescence
- birefringence
- conductivity

Bio-applications
Fabrication using bio-compatible resins to biological applications

- tissue engineering scaffolds
- fabrication of microneedle
- cell study
linear cationic polysaccharide obtained by deacetylation of chitin, which is normally found in crustaceans.

Applications
biodegradability
biocompatibility
bone regeneration
drug-delivery
bactericide action
blood coagulation
Resin Preparation

Monomers

SR499

\[
\begin{align*}
\text{CH}_2\left(\text{O-CH}_2\text{-CH}_2\right)_2\text{O-CH-CH}=\text{CH}_2 \\
\text{CH}_2\text{-CH}_2\text{-CH}_2\left(\text{O-CH}_2\text{-CH}_2\right)_2\text{O-CH-CH}=\text{CH}_2 \\
\text{CH}_2\left(\text{O-CH}_2\text{-CH}_2\right)_2\text{O-CH-CH}=\text{CH}_2
\end{align*}
\]

reduces the shrinkage upon polymerization

SR368

\[
\begin{align*}
\text{CH}_2\text{-CH}_2\text{-CH}_2\text{-O-CH}_2\text{-CH}_2\text{-N-CH}_2\text{-CH}_2\text{-CH}_2\text{-O-CH-CH}=\text{CH}_2 \\
\text{CH}_2\text{-CH}_2\text{-CH}_2\text{-N-CH}_2\text{-CH}_2\text{-CH}_2\text{-O-CH-CH}=\text{CH}_2
\end{align*}
\]
gives hardness to the polymeric structure

Photoinitiator

Lucirin TPO-L
Resin preparation

- ethanol solutions containing SR368 (70%), SR499 (30%) and chitosan (1-20% by weight)

- ethanol is eliminated by evaporation at room temperature for 24 h

- add the photoinitiator (1% by weight) one hour before use
Two-photon polymerization setup

Ti:sapphire laser oscillator
- 130 fs
- 800 nm
- 76 MHz
- 20 mW

Objective
- 40 x
- 0.65 NA
Two-photon polymerization

After fabrication, the sample is immersed in ethanol to wash away any unsolidified resin and then dried.
SEM of microstructures containing chitosan

Microstructures show excellent integrity and good definition.
Hardness measurements

![Bar chart showing hardness measurements for different materials.](chart.png)
Raman Spectroscopy

\[ \lambda_{\text{exc}} = 514 \text{ nm} \]
**Conclusion**

We demonstrated the fabrication of microstructures containing chitosan via two-photon absorption polymerization.

The microstructures present integrity and good definition, allowing applications in bio-related fields.

**Current work**

- IR absorption of the microstructures
- Two-photon absorption spectrum of Chitosan
- Cell growth studies (fibroblast)
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