INSTITUTE OF PHYSICS

REAL-TIME FABRICATION OF MICROSTRUCTURES ON THE MODIFIED CHITOSAN

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❑ Microstructures, produced on various materials such as: photoresists, polymers, composites, photosensitive glasses, etc., have a many applications in biomedical devices, microfluidic, lab-on-a-chip (LOC), displays, sensors, smartphone cameras, artificial compound eyes, security... Direct laser writing (DLW), hot embossing, thermal reflow, droplet process, etc are different methods used for the microstructures fabrication. However, most of these methods are mainly very complex, multistep, time-consuming, expensive processes, and often require the use of the poisonous chemicals.

❑ Chitosan, as a natural polymer extracted from crustaceous shells, was modified to be photosensitive, elastic, biocompatible, nontixic, and ecofriendly material suitable for the rapid, one-step fabrication of various microstructures (microlenses, diffraction gratings, microchanels...) that can be used directly without additional chemical processing.

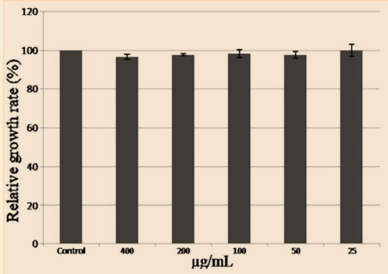
❑ Optically transparent photosensitive modified chitosan (MC) layer composed from: 2% chitosan, mixture of plasticizers, humectants, and preservatives, and sensitizer (anthocyanin food dye E163), was prepared by the gravity settling method on a very clean microscope glass slide. Than, the MC layer is dried under normal laboratory conditions (T = 25°C, RH = 50 - 60%).

❑ In vitro testing of the material biocompatibility showed that MC was evaluated as nontoxic to the HaCaT cell line with respective IC_{50} values of > 400 mg/mL, a concentration which is considered as the limit of toxicity.

❑ The home made DLW device was used for microstructure fabrications (laser operating at 488 nm, with maximal output power of 100 mW). The laser beam was focused with microscope objective (MO).

❑ The XY table (with step resolution of up to 25 nm and position repeatability of 2 µm) was used for positioning the sample (MC layer).

❑ Software developed in Microsoft Visual Studio reads an image file and sends control data to the programmable controllers which coordinate translation stage, and the shutter.



Relative growth rate of HaCaT cells in the presence of different MC concentrations

❑ The microstructures are produced by direct blue laser radiation with a power of 50 mV with an exposure time of 200 ms. The physical properties of microstructures depends on the layer absorbance, surface tension, and laser power.

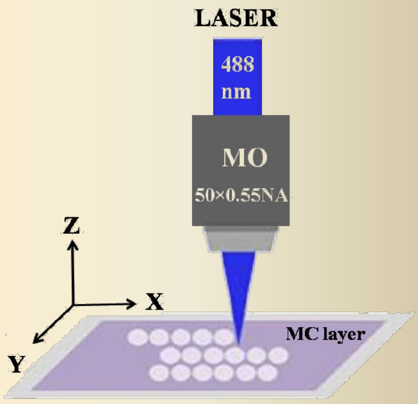
❑ The concave dip was formed on the MC layer by controlled, local melting. Following the laser beam profile, the surface tension forces form a concave dip, without any waste.

❑ Good quality convex lenses were produced by making an arrangement of 8 (or 6) polygonally positioned spots. The spherical surface in the polygon center acts as a convex (positive) microlens.

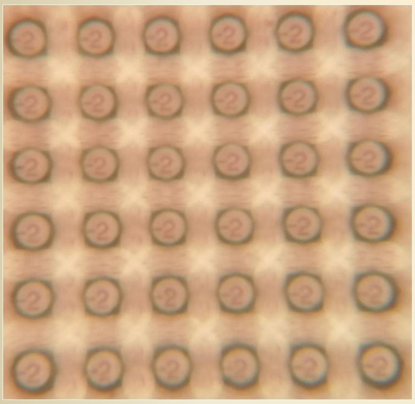
❑ The concave or convex microlenses are obtained with good repeatability.

❑ Diffraction gratings, microchannels, and various complex microstructures can be produced, also.

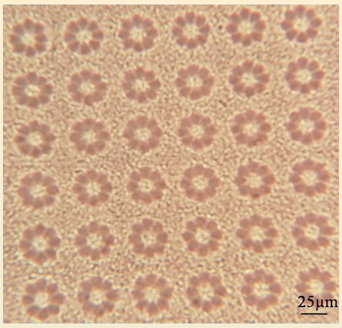
❑ Preliminary results have shown that MC layer elongation of 100% was obtained. The layer elasticity is very important for the fabrication of tunable microstructures.



Experimental setup

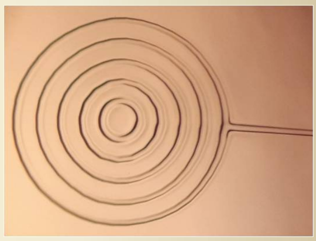


Transmission image of digit "-2" recorded by a digital camera through the optical microscope and 6x6 MC convex microlenses array



Reflection image of an array of 6 x 6 convex microlenses on the MC layer

Diffraction grating on the MC layer recorded by a digital camera through the optical microscope



Microchannels on the MC layer recorded by a digital camera through the optical microscope

SUMMARY

- Chemicals used to prepare modified chitosan (MC) layer are nontoxic, as confirmed by biocompatibility tests.
- MC is easy to prepare, cheap, biocompatible, ecofriendly, elastic, optically transparent, durable material.
- Microstructures fabrication is rapid, single-step process with the possibility of using cheap lasers.
- A variety of microoptical components (convex, concave microlenses, gratings, microchannels...) can be produced.
- They can be used immediately, after fabrication, without additional chemical processing, and any waste.
- The individual and closely packed hexagonal or square arrays of microlenses show good optical and imaging properties.
- Microstructures has important potential for a wide range of applications such as: biomedical testing, lab on a chip, optical sensors, light-field cameras, security, biological structure...

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