# Electrohydrodynamic Patterning and Surface Control


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## Introduction

**"Bottom-up" processing enables new ways of structuring thin polymer films. The characteristics of bottom-up processed polymers bear many advantages over "top-down" processed polymers, such as: better adherence to the substrate and the possibility of surface functionalisation. The drawback is a more complicated experimental- and manufacturing setup than in top-down processing. By combining the bottom-up with top-down techniques as in electrohydrodynamic pattering, all advantages can be combined.**

**High transparency epoxy materials (HTP1 and HTP2) are predestined for bottom-up approaches due to their controllable polymerisation kinetics and superior material properties.**

## Surface functionality by "bottom up" processing

**Epoxy based HTP can be cured using a photoacid generator that is initiated by near UV light. By bottom-up curing through a mask, and UV dose control it is possible to create structures that have a high surface functionality.**

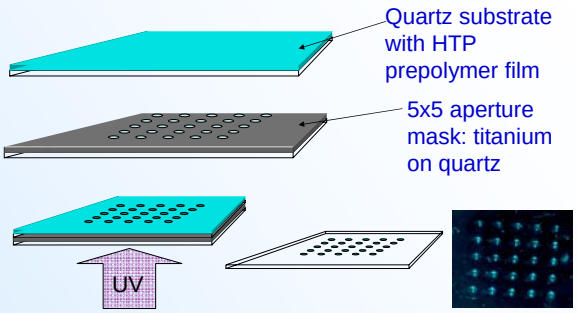


**Figure 1:** Bottom-up curing of the HTP prepolymer. A prepolymer film is spread onto a quartz slide and exposed to UV light through a (here 5 x 5 100µm aperture) mask. After wash-off, polymer domes are obtained. that adhere well to the quartz. (Bottom right: photograph of functional polymer domes)

**The material is first cured at the substrate prepolymer interface and polymerisation then proceeds upwards. The UV exposure is stopped before the film is fully cured and the excess materials is washed off, so that a gelled but not fully polymerised surface is obtained. By this, many epoxy groups on the surface are unconsumed and can hence be reacted in subsequent treatments.**

## Surface attached oligonucleotides for bio-analytical application

**One possibility is attachment of amine terminated oligonucleotides to the surface. These single strands of DNA can be hybridised with a complementary strand that is labelled with a fluorescent dye. This fluorescent dye only fluoresces if complementary strands are hybridised. We have proven attachment of the hybridised strands to the polymer by confocal microscopy. The outcome shows only the surface of the polymer dome was fluorescing and hence functionalised with oligonucleotides.**

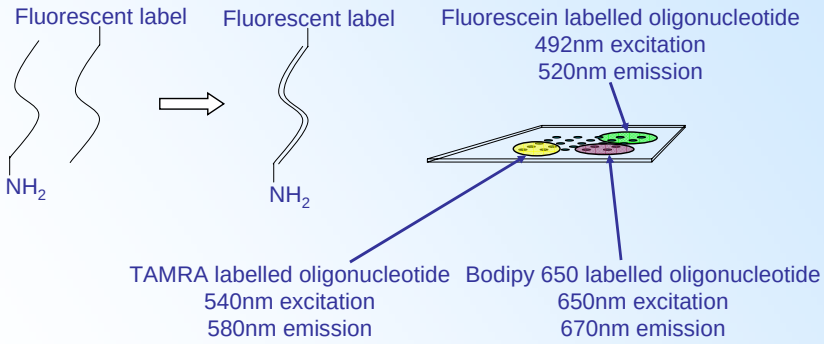


**Figure 2:** Left: amine functionalised oligonucleotides that hybridise with complementary strand bearing a fluorescent label. Right: experimental setup; 5 x 5 array of polymer domes functionalised with three different types of oligonucleotide double strands with different fluorescent labels: Fluorescein, TAMRA, and Bodipy.

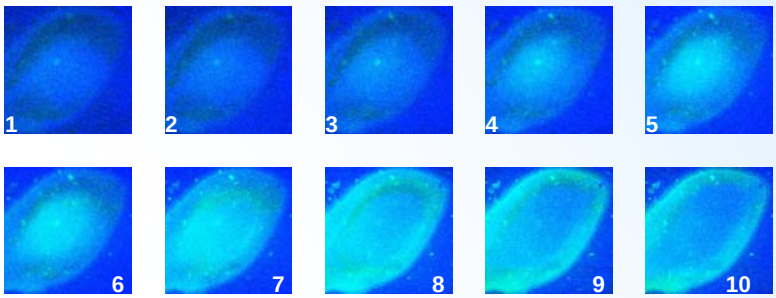


**Figure 3:** Sequence of confocal micrographs under 488nm laser illumination. The confocal microscope cuts through layers of the polymer dome showing a point of fluorescence in pic. 1 distending into a ring shape pic. 10. This proves only the surface of the polymer dome is fluorescing and hence functionalised with oligonucleotides (not true colour images).

## Electrohydrodynamic patterning of thin HTP films

**A thin film of a dielectric polymer exhibits electrohydrodynamic instabilities in an electrical field. These instabilities can be utilized to structure the polymer film. During the process small areas of the polymer film grow towards the upper electrode. If this electrode is patterned, a positive image of this pattern is transferred into the polymer film. If the electrode is unpatterned the instabilities in the film relax while producing a hexagonal array of polymer columns that grow towards the upper electrode. This phenomenon has been investigated while using the epoxy HTP material and the structures were fixed by photocuring through a half transparent top gold electrode.**

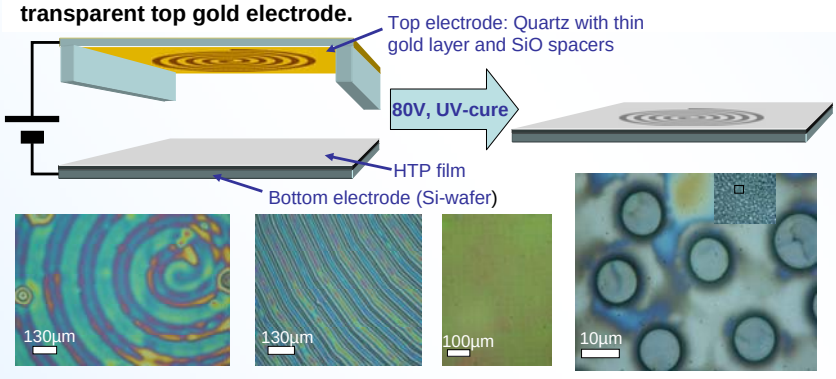


**Figure 4:** Experimental setup and micrographs of the photo cured films patterned by EHD forces.

## Conclusions

**It is possible to surface functionalise HTP materials which makes them very useful for lab-on-chip devices where surface reactions or -analysis make use of UV radiation. Also the materials can be structured via EHD techniques which can potentially overcome photolithographic size limitations.**