Wettability Control by Laser Ablation of GPOSS-PDMS Polymer Films

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Abstract. On-chip microfluidic devices have gained significant attention for their unique wettability properties. In this study, we developed a microfluidic chip by laser treatment of GPOSS-PDMS polymer film, achieving wettability variations influenced by specific ablation parameters.

1 Introduction

Smart materials with specific wettability properties have been of great interest for the last decade for their advanced applicability [1]. Selective omniphobic-omniphilic patterning of such materials has gained specific attention in various industrial and research applications, as surface-selective plasmonic sensing, high-throughput screening and molecular synthesis [2]. A classic solution for the smart material coating is a chip with a pure or modified polydimethylsiloxane (PDMS) material spin-coated on top of an optically transparent substrate material, typically glass. In this study we have addressed the wettability control of a thin film (~800nm thick) of PDMS-modified octa(3-glycidyloxypropyl) polyhedral oligomeric silsesquioxane (GPOSS-PDMS) [3] deposited on a glass slide surface and micropatterned by the means of laser ablation technique.

2 Materials and Methods

While UV-photomask lithography is usually considered as a proven technique [1] for micropatterning on polymer coatings, it has several limitations such as resolution and low flexibility of the patterned material. In contrast, laser ablation is a well-known method for wettability patterning [4] and manufacturing microfluidic devices, although its application to polymer surfaces is underestimated.

In our experimental study, we have treated GPOSS-PDMS films with single laser pulses generated by a YAG-based solid state laser system “Dirona” (Laser Center Ltd.) in a surface scanning mode (λ=355 nm, P=5 W, τ=13 ns, ν=20 kHz). The laser beam was focused on the surface of a glass slide with spot diameter D=15 µm. The laser treatment was performed as a process of subsequent scanning of vector-guided line patterns with density of 35 lines per mm (scanning speed 0,45 m/s). The average spot size value of the focused laser beam is S = 15 µm.

3 Results and Discussions

To achieve the distribution of ablation trace sizes the laser power was varied. The resulting micropatterns are shown in Fig 1 (a-c).

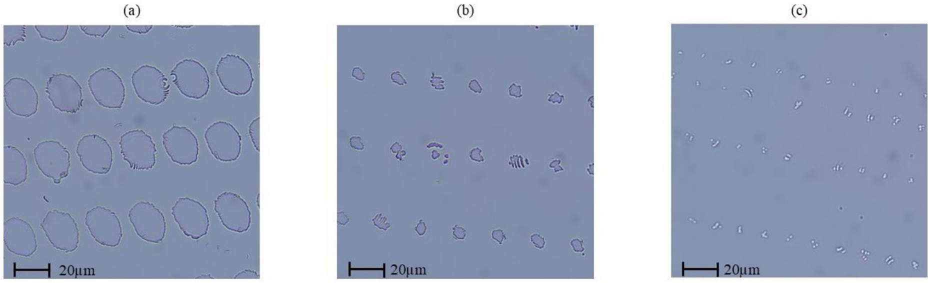

Fig. 1 The microscopic image of ablation pattern filmed with ADF C150 microscope. For the pattern (a) 30% of initial laser source power is applied, for (b) – 18% and (c) corresponds to 14% of total initial laser power respectively.

The correlation between measured average power (P, in Watts) and the average size of a single pulse trace is given by the Table 1 for each pattern (a–c)

Table 1. Correlations between pattern characteristics and laser treatment parameters.

	Power (P)	**Single trace size**	**Contact angle**
Pattern (a)	0,87 W	22,17 μm	104,7°
Pattern (b)	0.52 W	5,95 μm	102,8°
Pattern (c)	0,40 W	1,65 μm	98,8°

To compare the cumulative wettability properties of the pattern, the drop shape analysis has been conducted with Kruss DSA 25E set a Young-Laplace fitting mode. The contact angles of a water drop sized as V=2,0 μl are given by the Table 1, demonstrating a respective increase in hydrophilicity with a trace size decrease.

4 Conclusions

The correlations between the average power values and the single-trace morphology suggest the influence of spatial mode distribution in the optical fiber. While fig.1 (a) exhibits a rough round ablation trace, fig 1 (b,c) demonstrate random distribution of intensity within a single pulse ablation trace, resulting in a higher microstructuring resolution. Such a single-trace morphology suggests the influence of spatial mode distribution. This might result from pseudo-gaussian laser mode profile, inspired by Q-switching single pulse generation regime.

References

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