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Aerosil in Liquid Crystals

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The structure of aerosil in a liquid crystal was investigated by atomic force microscopy. Depending on the preparation of the sample different agglomerates of aerosil in the liquid crystalline matrix were detected.

Keywords: aerosil; agglomerates; AFM-measurements; liquid crystals

INTRODUCTION

Systems consisting of two phases are promising materials for electro-optical applications [1]. An interesting version are filled liquid crystals consisting of a suspension of solid particles in a liquid-crystalline matrix. Commonly aerosil is used as solid component [2]. Such mixtures show an electro-optical memory effect [3]. The nature of the memory effect is not completely under-

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stand at the time. Generally, it is accepted that the memory effect is based on the structure of the aerosil particles, its aggregation and interaction with the liquid crystal. Thereby hydrogen bonds play an important role. Two models are discussed at the time:

1. the network model (Eidenschink et al. [4]) and
2. the model of separated aggregates (Glushchenko et al. [3]).

The arguments for the second model are based on ultrasonic investigations. For this reason we have prepared our samples in two different ways: with (**U**) and without (**N**) influence of ultrasonic waves. We used the atomic force microscopy (AFM) to investigate the aggregates of aerosil in a glassy liquid crystal.

EXPERIMENTS AND DISCUSSION

The siloxane C4754L (g 55 N* 216 I) produced by WACKER Chemie was used as liquid crystalline component. It was mixed with aerosil 300 (mean particle diameter about 7 nm, obtained from DEGUSSA). Mixtures with **4.75** and **18** weight percent aerosil in C4754L were solved in about 1 g CH_2Cl_2. The first sample was taken from the solution (**N**). For procedure **ND** a Si-wafer was dipped directly in the solution and dried for three days at room temperature. A second sample was prepared in the same way and after that heated to 220 °C and cooled down with 20 $Kmin^{-1}$ to room temperature (**NH**). For a further set of measurements the solution was treated 20 min with ultrasonic waves (**U**) and prepared in the above described two ways on a wafer (**UD** and **UH**). For all the investigations given in Figures 1-8 thin layers on the wafer were used in order to avoid fingerprint textures of the cholesteric liquid crystal.

AFM-measurements were performed using the TMX 2000 Explorer and Discoverer Scanning Probe Microscope of TOPOMETRIX at room temperature and ambient conditions. The images were obtained by the non-contact method.

AFM-images of procedure **ND/4.75** show only statistically distributed aerosil aggregates with a diameter between 20 and 250 nm. Heating of the sample (**NH/4.5**) results in agglomeration of the aggregates. The same agglomerates can be observed also without heating at higher concentrations as demonstrated in AFM-image of **ND/18** (Fig. 1). To see better the building units of agglomerates the central part of Figure 1 was magnified. The

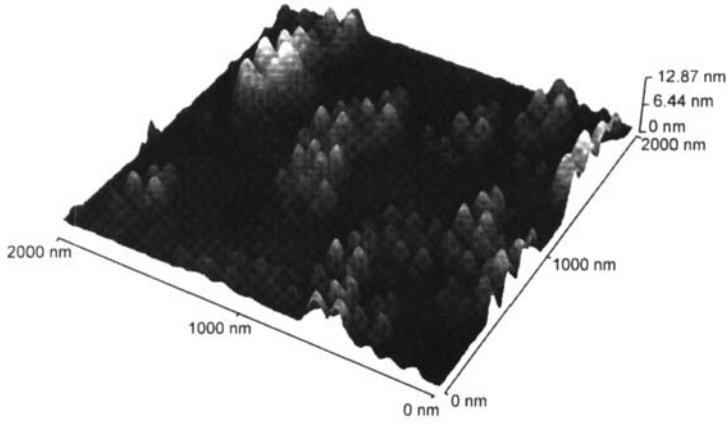

FIGURE 1: AFM-image of the mixture **ND/18** on a Si-wafer

respective image in Figure 2 confirms that nearly spherical particles are agglomerated. Line measurements in Figure 3 prove a aggregate size of about 120 nm.

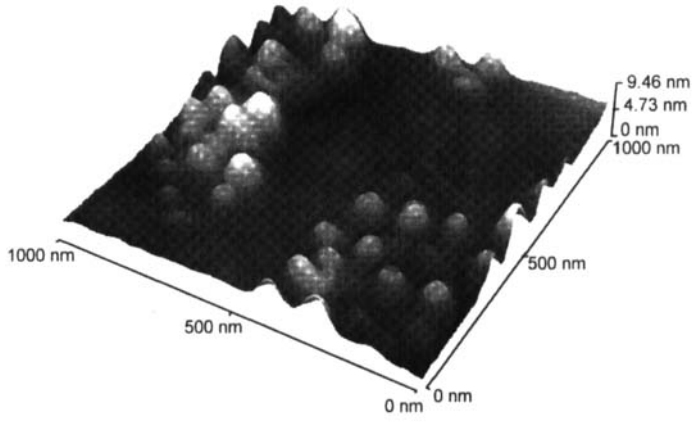

FIGURE 2: AFM image of the centre part of Fig. 1.

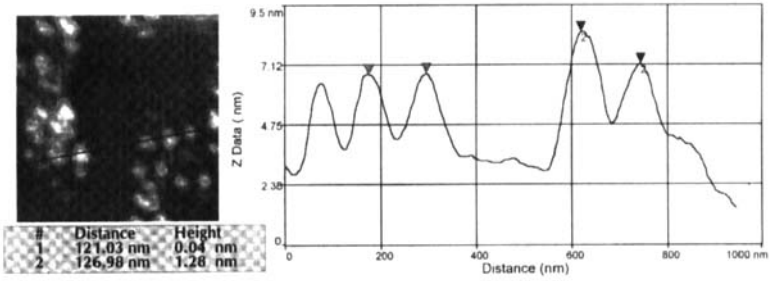

FIGURE 3: Line measurement of the AFM image in Fig. 2.

The surface structure of a thin area after heating (**NH/18**) is given together with a line plot in Figure 4. The distance between the aggregates and the size of agglomerates are the same as before.

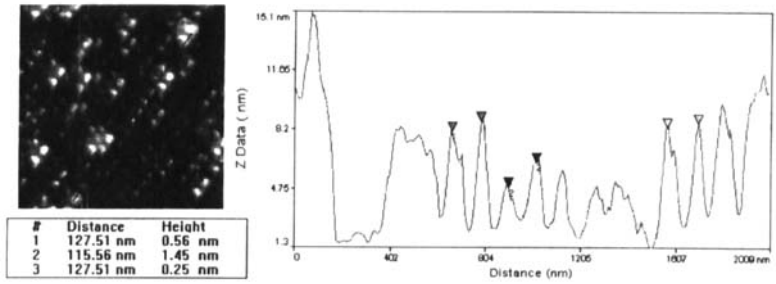

FIGURE 4: Line measurement of sample **NH/18**.

A second part of the CH_2Cl_2-solution was treated with ultrasonic waves and prepared on a wafer **(UD/18)**. In contradiction to Figure 1 the AFM image of a thin area shows a more singular distribution of the aggregates without

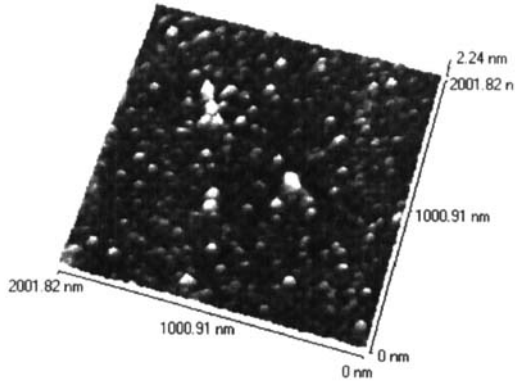

FIGURE 5: AFM image of a thin area of sample **UD/18**.

agglomeration (Figure 5). Diameters from about 40 to 130 nm are seen by line measurements (Figure 6).

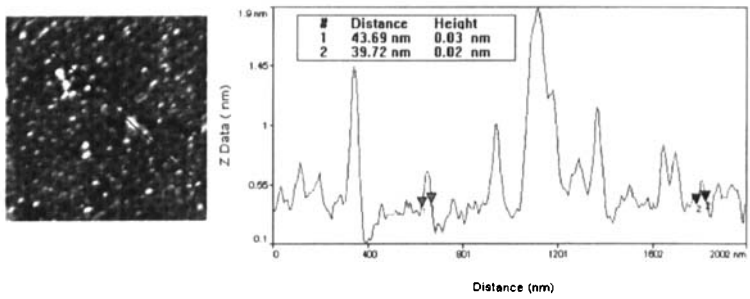

FIGURE 6: Line measurement of sample **UD/18**.

The small aggregates may consist of about 30 aerosil particles in a plane. The AFM images of the heated sample **UH/18** show the same surface pattern as presented in Figure 5 and 6. Similar behavior is observed also for the lower concentrations **UD/4.75** and **UH/4.75**. As example the AFM image of **UH/4.75** after heating is shown in Figure 7.

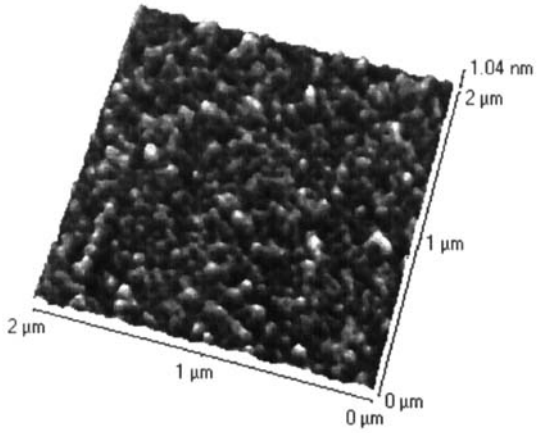

FIGURE 7: AFM image of **UH/4.75**.

Line measurements on the sample **UH/4.75** show singular aggregates but also holes of nearly the same diameter in the thin area (Figure 8).

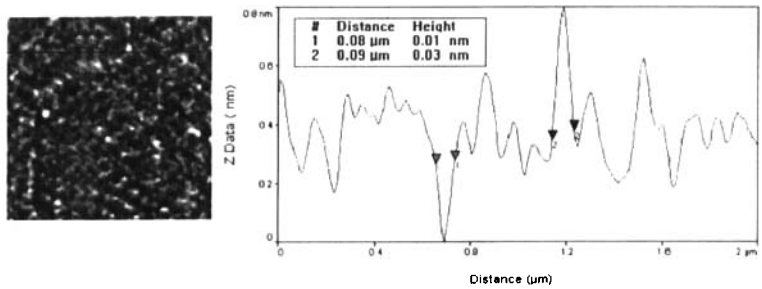

FIGURE 8: Line measurement of **UH/4.75.**

About 300 nm thick areas of samples **UD/4.75, UH/4.75, UD/18, UH/18** are characterized by agglomerates embed in liquid crystalline surrounding. This is demonstrated in Figure 9 where the AFM image of **UH/18** is given. Agglomerates of 1 µm diameter can be seen. They are build up from aggregates with a mean diameter of 60 nm. In the areas thicker than 300 nm cholesteric fingerprint textures were observed.

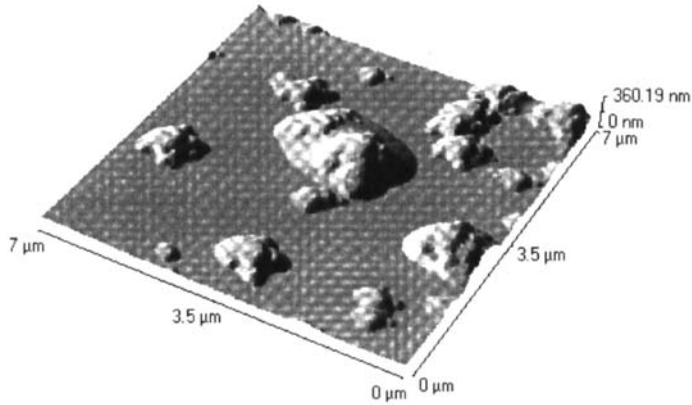

FIGURE 9: AFM image of **UH/18** (thicker area).

CONCLUSION

In conclusion we have to say that the model of separated agglomerates was directly proven. Without ultrasonic treatment rod-like aerosil agglomerates were observed. Ultrasonic waves reduce the diameter of the aggregates. In bigger samples also 1 μm agglomerates can be seen. The observed complex structure is the reason for a complicated electro-optical switching behavior.

Acknowledgements

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