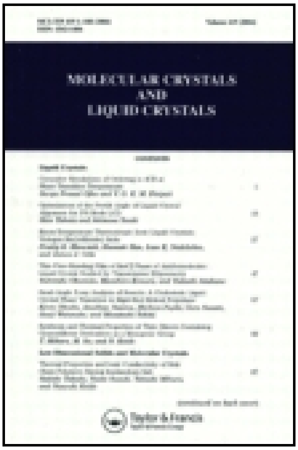

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Jitter-Free Nano-Spheres Data Storage System

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Version of record first published: 26 May 2010

Mol. Cryst. Liq. Cryst., Vol. 505, pp. 44/[282]–50/[288], 2009

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400902941658

Jitter-Free Nano-Spheres Data Storage System

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In this research, a jitter-free optical storage media with high density is realized by using nano-spheres as digital recording bits. The media has an arranged structure composed of 300 nm diameter polystyrene spheres on the thin PMMA film. The optical shape signal reflected from nano-spheres is scanned with a confocal laser scanning microscope. A pickup reconstruction signal including a clocksignal is measured from the optical shape signal. This storage device is expected as a jitter-free media because no electrically-produced clocksignal is necessary for the pickup procedure.

Keywords: clock signal; confocal laser scanning microscope; jitter free; nano spheres; optical storage system

1. INTRODUCTION

In order to avoid a problem of the jitter, or instability of rotating disk speed and fluctuation of forming bit sequence, a new process should be devised.

In our laboratory, a jitter-free optical storage medium with high density has been realized using 500 nm diameter nano spheres as digital recording bits [1]. In this paper, we report a new medium with a buffer ring having an arranged structure composed of 300 nm diameter polystyrene spheres on a thin poly(methyl methacrylate) (PMMA) film. The medium's capacity has increased by 278% per one layer. An optical shape signal reflected from nano spheres is scanned with a reflection-type confocal laser scanning microscope which has high spatial resolution along the optical axis. A pickup reconstruction

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signal including a clocksignal can be measured in the optical shape signal.

2. EXPERIMENT

Polymer nano-spheres with a diameter of 300 nm (variance coefficient of equal to or less than 3%, in 10 wt% aqueous suspensions) and Sodium Dodecyl Sulfate as a surface-active agent were used for the experiments.

Figure 1 summarizes the process to make the nano-spheres medium. For the fabrication by use of the nano-spheres medium, first, a 26 mm $\times$ 38 mm glass plate is spin-coated with PMMA in 4.0 wt%. The PMMA was dissolved in the cyclohexanone. Spin rate is 1st:500 rpm 3 sec, 2nd:3000 rpm 10 sec. It is baked for 2 hour at 60°C. The sodium dodecyl sulfate is used as the surface active agent. The critical micelle concentration of this surface active agent is 8.5 mM (M = mol/l). A nano-spheres suspension is compounded of 10 mM surface active agent and nano spheres. The mass rate is 1:1. Second, the PMMA thin film is spin-coated with the nano-sphere's suspension. Spin rate is 1st:500 rpm 3 sec, 2nd:2000 rpm 10 sec. It dries naturally for 1 hour in desiccators. Very little clearance between adjacent spheres is formed by changing the density of PMMA, the density of surface active agent, the spin rate and the dry method.

Figure 2 shows the optical setup for the reflection-type confocal laser scanning microscope. The reflection-type confocal laser scanning

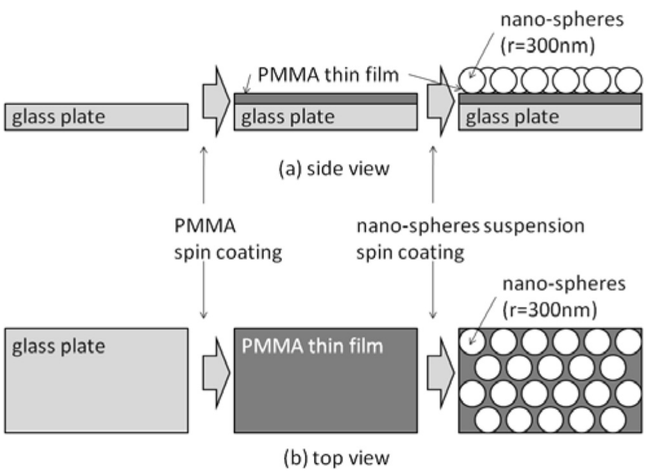

FIGURE 1 The process to make the nano-spheres medium.

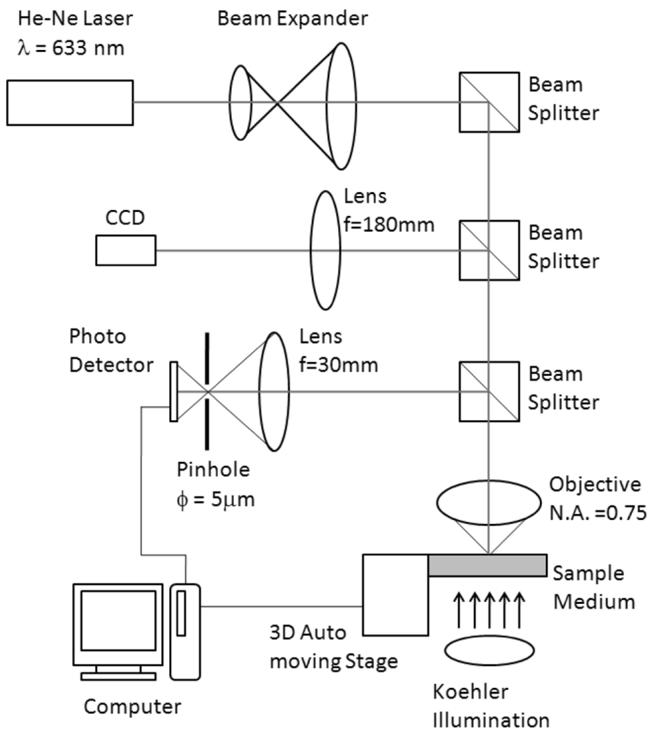

FIGURE 2 The optical setup for reflection type confocal laser scanning microscopy.

microscope as a measurement system has a He-Ne laser ($\lambda = 633\,\text{nm}$). The laser light is expanded 5 times with a beam expander. Since we will add a Nd:YAG laser ($\lambda = 532\,\text{nm}$) as a recording light in this optical setup. The first beam splitter is used to reflect the light. The expanded beam is focused through an objective lens onto the sample surface. The N.A. of the objective lens is 0.75. The reflection signal from the sample surface is measured through a pinhole ($\phi = 0.5\,\mu\text{m}$) with a photo detector. The sample is set on a 3D auto stage. The 3D auto stage is controlled with a computer. The approximate sample position is checked with a transmission-type Koehler-illumination and a CCD image sensor.

Figure 3 shows the normalized reflected signal along the optical axis. The Full Width, at Half Maximum, is defined as the microscope's resolution. The resolution in the optical axis direction is 1.25 μm. The size of nano sphere is 300 nm. The confocal reflected signal from

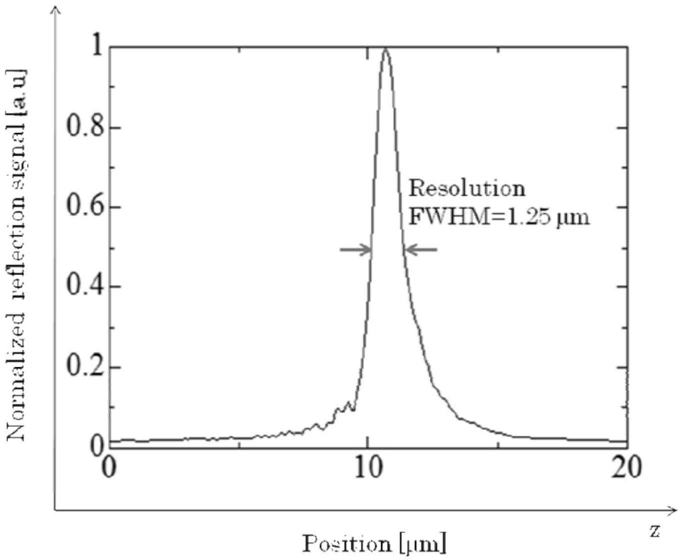

FIGURE 3 The normalized refraction signal in the optical axis.

the nano sphere is measured at sufficient intensity because of high image contrast.

3. RESULTS AND DISCUSSION

The PMMA film was spin-coated on the glass plate. The surface tension between the PMMA film and the nano-spheres suspension was adjusted by changing the density of PMMA. The little clearance acts as a buffer for high S/N (signal to noise fraction) bits reconstruction. The size of the little clearance is regulated by the surface tension between the PMMA film and the suspension. Figure 4 shows the nano-spheres surface micrograph with atomic force microscope (AFM). Nano spheres were arranged as a monolayer on the thin PMMA film. The nano spheres were arranged hexagonally semi-close packing with very little clearance between adjacent spheres on the thin PMMA film. The image tells us that each of nano spheres has a buffer ring around them.

The sphere's shape signal is read out at high image contrast with a reflection-type confocal optical microscope. The reflected shape signal from each sphere is utilized as a clock signal in recording and readout. In the optical storage system, no time lag between positions of the

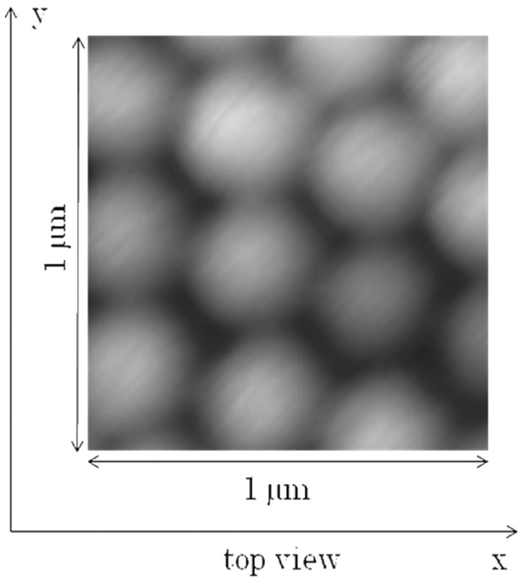

FIGURE 4 The nano-spheres surface micrograph with the atomic force microscope.

recorded bit sequence and the clock signal occurs because the clock signal is generated from its shape signal.

Figure 5 shows the optical shape signal generated from nano spheres by the reflection-type confocal laser scanning microscopy. The measurement position with the confocal microscope is determined with the AFM preciously. Figure 5 seeks to capture the fact that the clearance between spheres leads to the high image contrast near the boundary. The boundary was emphasized as a phase inversed image. The nano spheres medium arranged hexagonally semi-close packing in a large area has the little clearance as the buffer even in the use of the microscope. The max contrast is 1.00 : 0.66. The shape signal as the reflection signal with the confocal laser microscope was analyzed in the y direction. Figure 6(a) and (b) show the reflection signal and pickup signals in the y direction at $x = 0.3$ and $1.2\,\mu m$. The high S/N pickup signals are used as the clock signal for our data storage system. The bottom diagrams illustrate the normalized clock signals reconstructed from the shape signals. The clock signal as a detection window is utilized for data decoding. Even in the non-periodic detection window, our system succeeded in jitter-free data decoding. No fluctuation of the sphere's

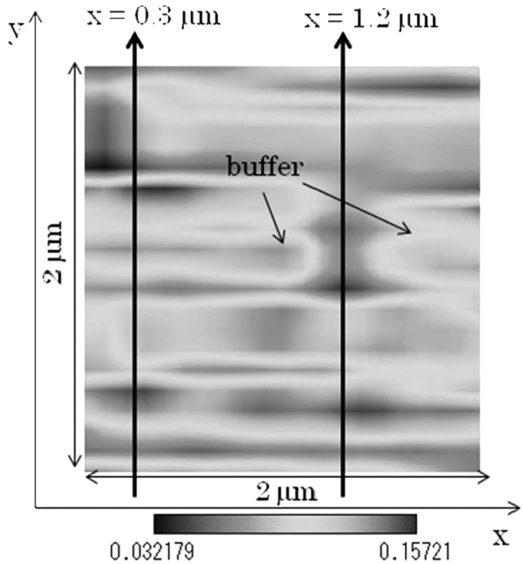

FIGURE 5 The optical shape signal reflected from nano spheres with the confocal laser scanning microscope.

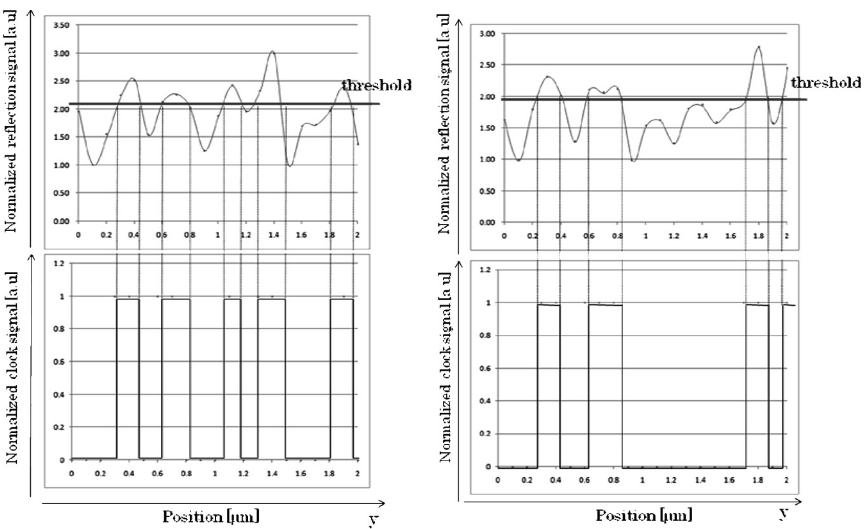

FIGURE 6 The reflection and pickup signals in the y direction.

position becomes a problem in the data reconstruction. This jitter-free technique proved to be extremely effective for disk recording and readout.

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