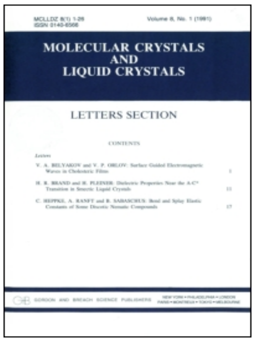

Molecular Crystals and Liquid Crystals

ISSN: 1542-1406 (Print) 1563-5287 (Online) Journal homepage: http://www.tandfonline.com/loi/gmcl20

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To cite this article: Kenta Suzuki & Chikara Egami (2016) Construction of three-dimensional optical disk with arrangement of particles and self-clock-signal generation, Molecular Crystals and Liquid Crystals, 635:1, 1-5, DOI: 10.1080/15421406.2016.1199943

To link to this article: http://dx.doi.org/10.1080/15421406.2016.1199943

MOLECULAR CRYSTALS AND LIQUID CRYSTALS
2016, VOL. 635, 1–5
http://dx.doi.org/10.1080/15421406.2016.1199943

Construction of three-dimensional optical disk with arrangement of particles and self-clock-signal generation

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ABSTRACT
The purpose of this study is to construct an optical disk that arranges submicron polymer particles and to generate a self-clock-signal for data reconstruction from the scattering signal itself of the particles. The optical disk has a monolayer structure with non-photosensitive buffer rings between each of the photosensitive particles. A polarization interferometric nonlinear confocal microscope picks up particle's shape signals of the optical disk. An auto-clock-signal is generated from the scattering signals.

KEYWORDS
Optical disk; submicron polymer particles; polarization-interferometric nonlinear confocal microscope; clock signal; jitter free

1. Introduction

A capacity enlargement for an optical disk will become a big issue in the very near future because the amount of information is on the increase rapidly. However, the conventional storage methods to enlarge the capacity, such as shortening the wavelength of light sources and enlarging the numerical aperture of objective lenses, are getting close to their limits, which makes it difficult to boost the capacity of the optical disk.

In this study, an optical disk that arranges submicron polymer particles is proposed as a new optical recording device. The optical disk allows densification of its recording bits by arranging polystyrene particles of 200-nm diameter with xanthene-based compound dyes on a glass substrate. The diameter is 100 nm smaller than the previous report [3]. As a result, the storage capacity becomes 2.25 times. It is expected that no jitter occurs theoretically and its transfer rate will increase because a clock signal is directly generated from the scattering signal itself of the disk [2][3].

2. Experiments

We describe a method of making a particle-arranged optical disk. A schematic to make the optical disk is shown in Fig. 1. A glass substrate which measures 26-mm wide by 38-mm long by 0.9-mm thick is polished to improve its wettability. A drop of a solution that contains polystyrene particles of 200-nm diameter with xanthene-based compound dyes is spin-coated on the glass substrate. Polybead Polystyrene Blue Dyed Microsphere 0.20 μm (Polysciences, Inc.) is used as the solution. The size of the polystyrene particles becomes 100 nm smaller [3]. The following is the condition of spin coating rate: 1st is 200 rpm, 30 sec; 2nd

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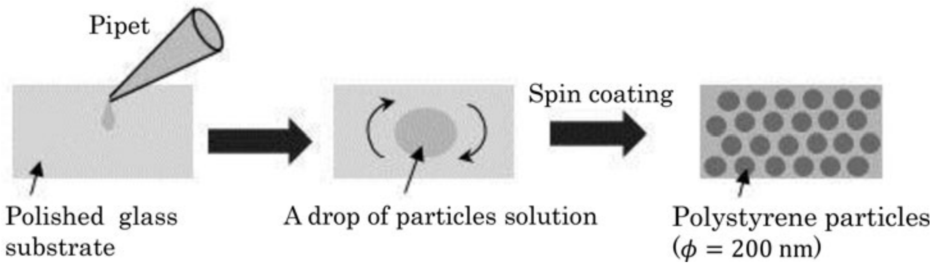

Figure 1. Process of making optical disk.

is 1000 rpm, 10 sec. The spin-coated glass substrate is dried up at the temperature of 40°C for 60 min. Through these processes, each photosensitive particle is arranged in a hexagonal closest packed structure.

A polarization-interferometric nonlinear confocal microscope is used as a pick-up apparatus to measure the shape signal of the particles disk. This optical microscope, which is shown in Fig. 2, utilizes a semiconductor laser with a wavelength of 637 nm. The confocal microscope including the Michelson-type interferometer equips itself with a thin analyzer in front of a pinhole to allow for polarization-vector interferometry between two orthogonal polarization components. Rotating the analyzer's transmission axis by some degrees with respect to that of the focused beam's polarization modulates the amplitude of a scattering signal passing through the analyzer.

Next, we shall consider the axial and lateral resolutions of the optical microscope. On the one hand, in this study, full width at half maximum (FWHM) defines the axial resolution. The optical microscope provides the 160-nm FWHM as shown in Fig. 3. The FWHM of the optical microscope is sharply improved as compared with that of conventional confocal laser scanning microscope [1][2][3]. On the other hand, the point-spread function describes the response, or the lateral resolution, of a total imaging system to a point source or point object. Each particle is considered as a point light source when the particle is measured with the optical microscope. Scattering signals generated from each particle are given as integrated values of the point-spread function. These values have high contrast because the optical disk has a structural modulation with non-photosensitive buffer rings between the particles. Hence the optical microscope is suitable for the measurement of the particles disk.

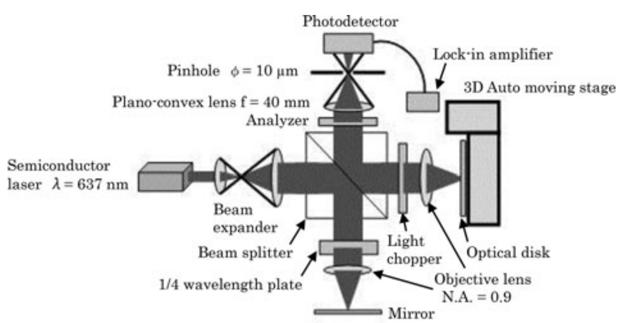

Figure 2. Optical apparatus for polarization-interferometric nonlinear confocal microscope.

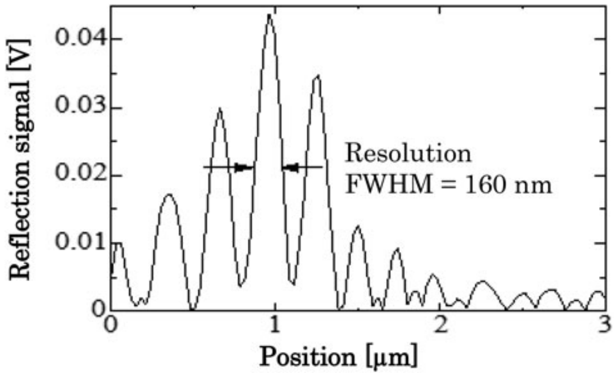

Figure 3. Reflection signal in the optical.

3. Results and discussion

Firstly, the surface of the optical disk is observed with an atomic force microscope (AFM). Fig. 4 shows a micrograph of the surface morphology of the optical disk. Fig. 4 confirmed that the optical disk has a hexagonal closest packed structure with extensive non-photosensitive buffer rings between the photosensitive particles.

Secondly, the polarization interferometric nonlinear confocal microscope measures the optical disk surface. Pit data is reconstructed from the scattering signals. The scanning area of the optical disk is 2 μm x 1 μm. The image of the scattering signals of the optical disk is shown in Fig. 5. The circles written in dashed lines show particles and the spaces between the particles indicates buffer rings. Fig. 5 demonstrates that the scattering shape signals for pit data reconstruction have a high contrast. The lowest value is extremely close to zero in Fig. 5, which means that the polarization interferometric nonlinear confocal microscope improves

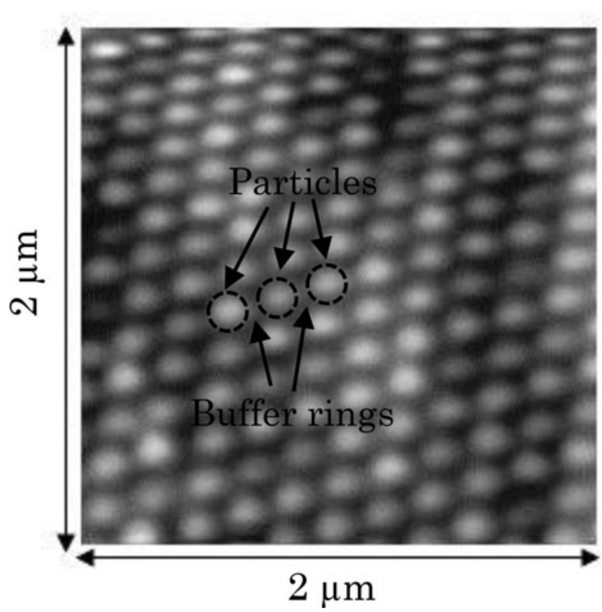

Figure 4. : Particles-disk surface micrograph with atomic force microscope.

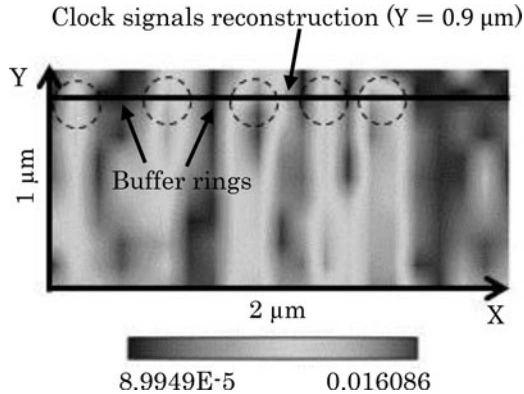

Figure 5. Scattering signals of optical disk.

its lateral resolution compared with that of the conventional confocal laser scanning microscope [2][3]. The high contrast is attributed to the high resolution of the optical microscope and the effect of buffer ring. In the next step, a shape signal of the arranged particles is scanned at Y $= 0.9$ μm.

Thirdly, a clock signal that is necessary in order to reconstruct the optical disk is generated from the scattering signal. Fig. 6 shows the readout of the scattering shape signal along Y $= 0.9$ μm in Fig. 5. The threshold is set to 0.006 V. This threshold provides the non-periodic clock signal with 11 orders of magnitude. It is a great advantage that the allowable range of the threshold becomes wide because of the high contrast, and this advantage will provide the reduction of readout bit error rate (BER) when recorded data on the optical disk is played back. Although the generated binary clock signal is non-periodic, this character will not become a problem for the particle-arranged optical disk because the scattering shape signal itself generates a detection window for data decoding; no fluctuation of the particle's position becomes a major problem in the data reconstruction. No electrically-produced reference signal is necessary for clock data recovery (CDR); no jitter occurs in data decoding.

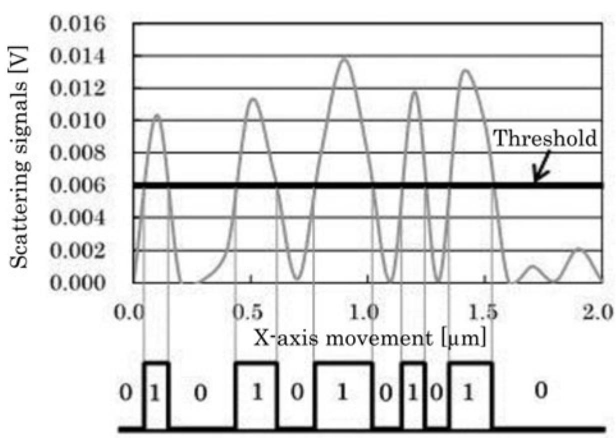

Figure 6. Generation of clock signals from arranged particles of scanning area.

4. Conclusion

In this study, the particle-arranged optical disk is proposed as a new optical recording device. The scattering signals from the optical disk are measured with the polarization interferometric nonlinear confocal microscope to generate auto clock signals. The optical microscope provides the high contrast image of scattering signals of the optical disk. Clock signals are necessary to play this device. Generation of the non-periodic clock signals from the scattering signals leads to 11 orders of magnitude.

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