Manufacturing Methods for a Flexible Optical Disk (FOD)

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1. Aim

Thin optical disks (such as a flexible optical disk, FOD, hereafter) are drawing much attention because they can provide high volumetric recording density on a thin disk with high-speed data transfer thanks to air stabilization. Since the thickness of an FOD is in the range of 0.1 to 0.2 mm, however, conventional fabrication processes for DVDs cannot simple be applied as is to fabricate an FOD. This report describes some FOD fabrication methods tested by the authors.

2. Trial production

The process flow for fabricating the FOD is shown in Figure 1. Owing to the thinness of the FOD, many steps of the FOD fabrication process are different from those of conventional processes; those steps—namely, pre-format formation, recording-film formation, and overcoating—are described in the following sub-sections.

2-1. Pre-format formation for film

Ultraviolet (UV)-curing resin is dropped onto a stamper, and the resin is spread out by centrifugal force produced by coaxial spinning. After that, the resin is cured, and the cured film is peeled off the stamper. At that time, variation in transfer-layer thickness, which is dependent on the characteristics of the UV-curing resin used and is manifested in a significant difference in the focus-servo characteristic, can be seen. The appearance of the coating by UV-curing resin is shown in Figures 2 and 3. As shown in Figure 2, the stamper is attached to the spinner, and the UV-curing resin is spread out in a circular coating. After that, the circular film (which is cut bigger than the stamper) is placed on the stamper, and the spinner is rotated. During the spinning, the UV-cure resin is spread across the whole stamper. After the resin is spun, and then cured by UV irradiation, the cured-resin film is peeled off the stamper. The film thickness at that point varies in accordance with the type of UV resin used (see Figure 4). According to Figure 4, the resin composed of monofunctional monomer (namely, “UV resin D”) represents the best one from the viewpoint of low thickness variation. .

2-2. Formation of recording layer on film

When a normal retention jig for optical disks is used for sputtering, the coated film contains large undulations for the following reason. Since the film is loosely fixed, temperature rise during the film-formation process causes the film to undulate, and the recording film is sputtered in the form of those undulations. The following two methods for preventing these undulations were tried.

Method 1: The transfer film of the FOD is attached to a 0.6t hard-plastic substrate and sputtered by using a standard substrate-fixation jig. After processing such as transcription and film formation are completed, the film and the 0.6t substrate are separated.

Method 2: A jig that applies tension to a circular film is used to form the recording layer in the form of a film in taut state.

The state of the film produced by method 1 is shown in Figure 5. It is thought that if the film can be bonded to the substrate without bubbling between the two, the recording layer can be formed. Bubbles are, however, often generated between the film and the substrate, and these bubbles expand when the substrate is inducted into the vacuum chamber. Consequently, it has not been possible to attain a flat FOD.

The sputtering jig used in method 2 is shown in Figure 6. The recording layer is formed while radial tension is applied to the circular film so that the film does not undulate. Using this method results in few undulations in the film after sputtering. In light of these conclusions regarding methods 1 and 2, the sputtering of the recording layer on the resin film was performed by method 2 (i.e., the tension-application jig).

The results—namely, measured undulation when the disk is revolving ("axial runout of FOD" in the figure)—obtained by using methods 1 and 2 are, respectively, plotted in Figures 7 and 8. It is clear from these results that using the jig (method 2) makes it possible to perform sputtering of the recording layer with a standard sputtering machine for optical disks.

2-3. Overcoat for recording layer

The protective sheet for the film disk after the recording layer has been formed on it is formed by applying and curing a dry film resin. The dry film resin is processed in the form of a gel composed of a mixture of a UV-curing resin and a thermosetting resin. A key feature of forming the protective sheet by using a resin gel in this manner is that it is easier in comparison with spinning a coating film on a film-like disk and curing it.

3. Characteristics fabricated FOD

The fabricated FOD can record and reproduce signals at the same recording density as that of a Blu-ray disk. A concern, however, is variation with time of consequent warpage of the disk. To address that concern, a constant-humidity-and-temperature test (80°C/85% RH for 200 hours) was carried out on the fabricated FOB to investigate time-varying warpage of the FOB surface. According to the test result, although deterioration of the surface due to a certain degree of warpage was observed, the low value of the warpage (namely, less than 10 microns) means that the warpage is not a concern.

4. Concluding remarks

Two trail fabrication methods for a flexible optical disk (FOD) were described. The FOD is fabricated by means of steps such as pre-format formation with UV-curing resin, sputtering under tension application, and protective-sheet formation by using a dry-film resin. It can not only record and reproduce signals at the same recording density as that of a Blu-ray disk but also provides satisfactory storage stability.

Film cutting (ϕ150 mm)

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Pre format forming using UV-resin

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Film cutting (ϕ130 mm)

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Sputtering recording layer

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Bonding protective sheet (dry film resist)

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Film cutting (ϕ120 mm)

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Bonding center hub

↓

Completion

Fig.1 Manufacturing process for FOD

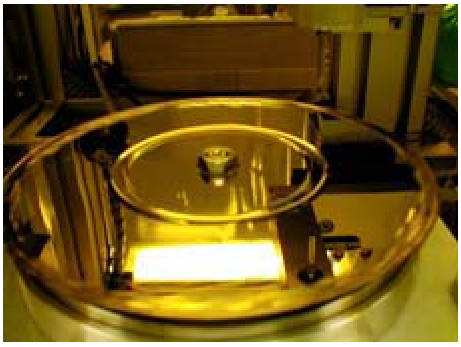

Fig.2　Applying UV resin on a stamper

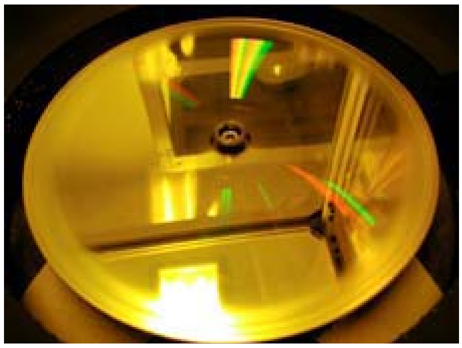

Fig.3　Spinning stamper with film

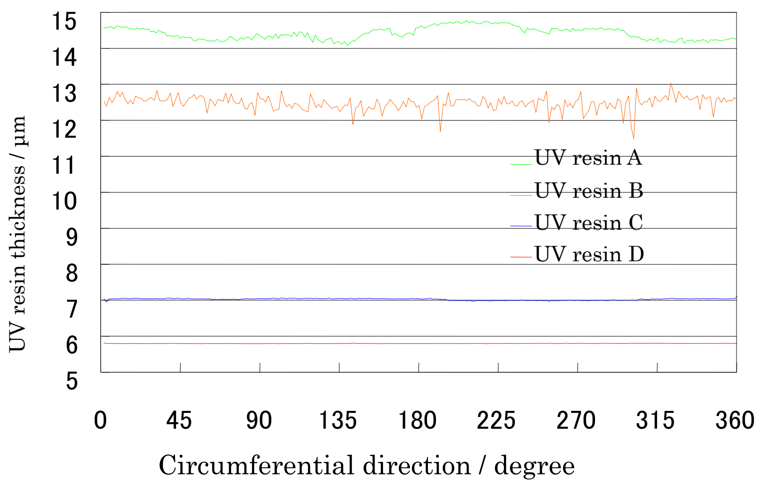

Fig.4 Thickness variations of UV resin layer on various materials

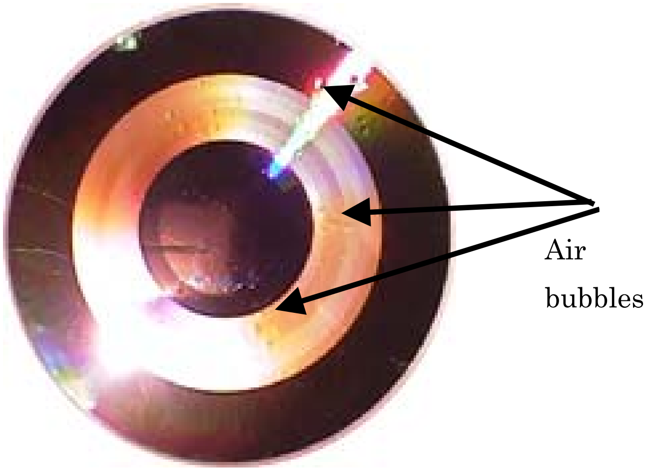

Fig.5 Film bonding on 0.6t PC substrate

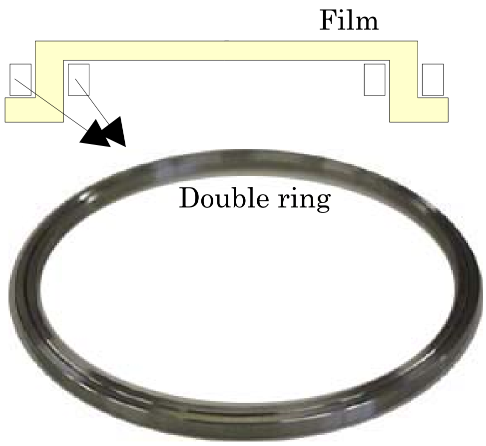

Fig.6 Sputtering jig

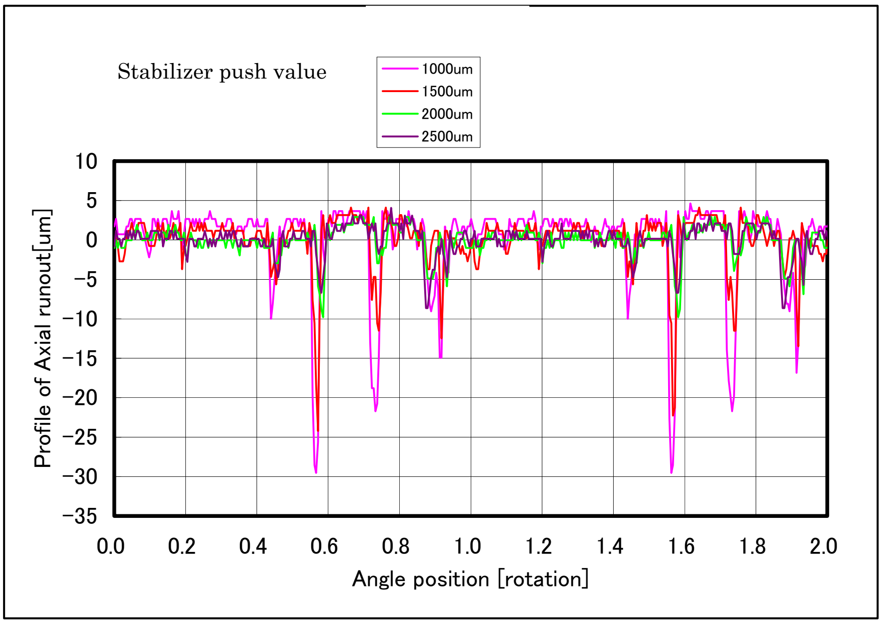

Fig.7 Profile of FOD axial runout made by bonding method

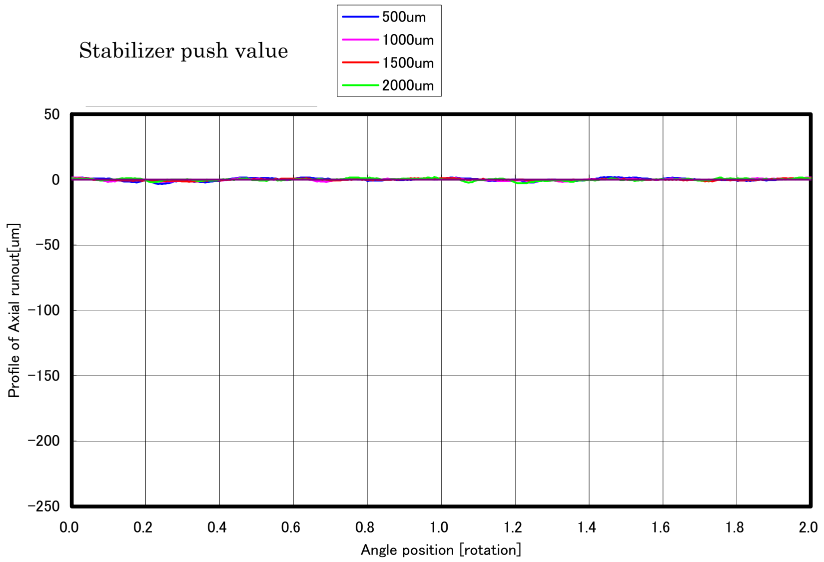

Fig.8 Profile of FOD axial runout made by double ring method