DOUBLE SIDED OPTICAL DISC SURFACE INSPECTOR

Field Of The Invention

This invention relates to the manufacture of optical discs, such as compact discs for the optical recording of digital data. In particular it relates to the quality control for defects of the surfaces of double sided optical discs during the manufacturing process.

Background Of The Invention

Compact discs are record carriers for digital or analog information, for example audio and/or video information, which have the form of a flat disc-shaped plastic surface on which a data modulated optical structure is provided in accordance with the information. The data is formed as pits of varying length present in the surface and arranged in a spiral path. The pits have nanometer dimensions and are formed by injection molding against a mold having corresponding raised regions. The information stored on the compact disc is recovered in a reader, usually called a player, which rotates the compact disc and guides a laser device along the spiral track as the compact disc rotates. The presence or absence of pits under the laser is detected as a change in the luminance returned from the surface directly below the laser. In this manner the length of the pits is detected and decoded as data. Recently double surfaced compacts discs have been proposed that are formed from two relatively thin compact discs that are bonded together with their readable surfaces exposed.

The creation of a compact disc requires the construction of the mold to be used in an injection molding process. In order to mass produce identical compact discs several stampers are prepared since each

has only a reasonable number of uses before it is degraded in the molding process. These stampers are prepared by coating thin metallic layers upon a surface having the inverse pit pattern, i.e. raised areas where pits are desired in the next generation of copies. The process begins with a surface called the compact disc.

The critical dimensions of the recorded pits on the optical disc are of the order of magnitude of the wavelength of visible light. Accordingly, it is critical to quality control that the surfaces of the produced disc be inspected for absence of imperfections of even micron size that can be detected as deviations from flatness of the disc surface. This must be accomplished as part of a mass production line. Presently discs are scanned on one side and a robot arm turns the disc over so that the second side may be scanned. What is needed is an apparatus for simultaneously scanning both sides of the compact disc without having to invert the disc in the apparatus.

There has been consideration of the detection of defects in or on disc surfaces by the use of light. In particular, U.S. patent 4,306,808 issued Dec. 22, 1981 for a "Disc flaw inspection system". This system employed a laser to scan lines across the surface from a very high angle of incidence in order to detect defects caused by tin dripping onto the disc. U.S. patent 5,311,276 issued May 10, 1994 for "Apparatus for detecting cut-edge flaws in disc plates". In this system, light from a linear light source was received by a 1-dimensional imaging device so that flaws in the cut edges of the disc were detected by a discriminator. U.S. patent 5,343,288 issued Aug.30, 1994 for "Optical evaluation of automotive disc". In this system a light was directed in narrow elongated beams. A line scan

camera array system scanned the display area and produced signals indicative of the position of images of the beams reflected by the opposite surfaces of the windshield. U.S. patent 5,309,486 issued May 3, 1994 for "Non-contact flaw detecting for cylindrical nuclear fuel pellets". In this system surface flaws were detected by using a line scan camera to record a series of scans and pixel values were compared to thresholds. U.S. patent 4,914,828 issued Apr. 10, 1990 for "Surface inspection device and method". This system measured surface irregularities on curved automotive disc by calculating the local radius of curvature between two points. U.S. patent 4,874,940 issued Oct. 17, 1989 for a "Method and apparatus for inspection of a transparent container". This system inspected the bottom of a container for internal stuck disc or foreign material. It used a linearly extending line of light, which when reflected from a defect exceeded a predetermined threshold value. U.S. patent 4,741,042 issued Apr. 26, 1988 for an image processing system for detecting bruises on fruit. The system employed a line scan camera to obtain a series of gray levels from the fruit as it rotated. The image was processed to determine size of bruise by assuming that the circular shape of a region of differing gray level should be interpreted as a bruise. U.S. patent 4,403,230 issued Sep. 6, 1983 for "Inspection of castings". A revolving camera is employed during the inspection for defects. U.S. patent 4,335,960 issued Jun. 22, 1982 for "Apparatus for detecting the presence of surface irregularities in articles made of transparent material". This apparatus detected spikes on the inside base of disc containers, which were passed rotatably over a slit having an opaque line in the slit. Two light sources emit light that refracted at an oblique angle through the

container base into a diode camera when there was an irregularity. U.S. patent 5,204,911 issued Apr. 20, 1993 for an "Inspection method using unique templates and histogram analysis". This system was used for detecting defects in products either stationary or on a production line. A line-scan camera was used to compare an image with values stored in a matrix corresponding to geometrical grid areas of the product. U.S. patent 5,147,047 issued Sep. 15, 1992 for a "Pellet inspection system". A linear portion of the pellet was inspected and digital data generated that is compared to a standard. During inspection the pellet was moved axially. U.S. patent 3,962,538 issued Jun. 8, 1976 for a "Flying spot scanning system with virtual scanners". In this system a symmetrical arrangement of prisms scans were made across a medium having a planar surface. U.S. patent 4,319,270 issued Mar. 9, 1982 for a surface inspection system for hot radiant material". This system used a multi-camera system on all sides of a hot radiant material transferred along a predetermined transfer line

Although the prior art has been concerned with the detection of the irregularity of surfaces and has used optical systems to determine the presence of such irregularities, none of the systems appear adapted to simultaneously view both surfaces in an assembly line production where the surfaces are separated by an opaque layer.

Brief Description Of The Invention

The present invention is a system for detecting imperfections of both planar surface of a double sided compact disc. The system includes a self-centering chuck for retaining the compact disc and allowing it to rotate beneath an illumination source so that it illuminates the

surface under test along a radius. By a radius is meant a narrow slit of the disc along a line from near its center to the edge of the disc or along a portion of a diameter. It is not necessary to include a central portion of the disc where no data is usually recorded.

The invention includes a pair of video cameras or other video monitoring devices for receiving light from the illumination source that reflects from the surfaces under study. The camera is a detection means, which is oriented to receive illumination reflected only from an imperfectly flat portion of the surface being inspected.

A stepping motor or other means for rotating is used to turn the compact disc through a number of positions during at least one complete revolution while it is exposed to the light source. The signal received in the video camera is then processed to compare the light level received with that from an assumed flat portion of the disc. If a significant discrepancy is found between the light reflected from different radii, the disc is rejected.

Brief Description Of The Drawings

Figure 1 is a perspective view of the compact disc in an inspection station of the present invention.

Detailed Description Of a Preferred Embodiment

Figure 1 shows a stage of an assembly line for the production of compact discs. A compact disc 1 is brought by a conveyer belt 3 into an inspection chamber (not shown) where it is detected by a sensor 5. A self-centering chuck 7 engages the compact disc through a hole in its center. The surfaces of the disc are both illuminated by light sources 9, which illuminate at least

a narrow radial strip 11 of the surface of each side of the compact disc. It is preferred to employ the line scan cameras 15 directly above each surface 17 of the compact disc. A line scan camera is preferred for this operation because it is capable of much higher spatial resolution than the traditional two-dimensional photosite video cameras.

A servo-motor 19 drives the shaft 21 and the chuck 7 to cause rotation of the compact disc beneath the camera 15. Prior to rotation of the compact disc, a reference line of video data is collected from the image of the disc beneath the line-scan cameras 15. The illumination sources 9 are preferably incandescent illumination that employs precise angles of incidence (depicted in the figure as lines emanating from the sources 9. These angles are chosen so that a surface of the compact disc without defects appears "dark" to the camera. Defects, such as the bump 23 in the view of the camera will appear "bright" to the camera.

The image of the camera is divided into pixels. Preferably 2048 useable pixels are employed across the array of the line scan camera. If all the pixels of the image generally appear "dark", the image is accepted as a reference image. If any pixels appear to be "bright" the disc is repositioned by rotation for a proper reference line until such a reference line is found. It is necessary to establish a template value and to compare this with the values of different radii, and not merely rely upon the simple association of brightness with imperfection and darkness with perfection.

To acquire a reference line an image processing algorithm known as "template matching" is used. It operates as follows: The line scan camera employs 2048 usable pixels across its array. The reference image is

comprised of 2048 8-bit (0-255) intensity values which correspond to the actual intensity distribution of light across the linear array. If the scan of the disc is to reveal no defects, the test intensity values should remain near the reference value within some small tolerance value. If the scan of the disc is to reveal defects, the test intensity values will deviate from the reference intensity beyond some tolerance which is predetermined by experimentation and practical specification. It has been found acceptable if the tolerance value is approximately 0.8% and the deviation be calculated as a mean square value of less than 0.6%.

The compact disc is rotated through angles so that the different radial scans slightly overlap at their edges. The stepping motor is then advanced until the entire surface has been scanned at least one time.

In the event that a defect is detected, a signal is generated to begin the removal of the flawed disc. The process is then repeated for each compact disc in the production line.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to preferred embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. Apparatus for detecting imperfections of a planar surface of a dual sided compact disc for use in the production of compact discs for the optical recording of data comprising

self-centering chuck means for retaining said compact disc,

illumination means for focusing light upon one radius of both planar surface,

detection means for receiving light from said illumination means reflected from said compact disc surfaces, said detection means oriented to receive illumination reflected only from an imperfectly flat portion of said planar surfaces,

wherein said detection means comprises optics for receiving said light,

means for rotating said compact disc through at least one complete revolution while exposed to focused light from said illumination means,

means for indicating rejection of said compact disc when the light level received by said detection means exceeds a value determined from prior light levels received from said compact disc surface.

2. The apparatus of claim 1 wherein said detection means comprises two video cameras and said value of light determined from prior light levels comprises light levels obtained prior to rotation of said compact disc surface.

3. The apparatus of claim 1 wherein said detection means comprises two video receivers that resolves the light reflected from said compact disc surfaces into a plurality of pixels and said means for indicating rejection comprises processing means for comparing light values to the intensity values of said pixels.

4. The apparatus of claim 1 wherein each of said

detection means is located directly above the position of a surface of the compact disc under inspection.

5. A process for detecting imperfections of both planar surface of a dual surface compact disc for the optical recording of data comprising the steps of

(a) placing the compact disc on a self-centering chuck,

(b) illuminating both surfaces of the compact disc along a radius by directing illuminating light inclined at an acute angle with respect to the axis of the compact disc,

(c) receiving light reflected from said surfaces in a detecting device oriented to not receive light from perfectly planar portions of said compact disc,

(d) recording a set of pixel values from a first operation of step (c),

(e) rotating said compact disc through at least one full revolution and comparing value of light intensity received with those recorded in step (d),

(f) rejecting a compact disc if the comparison of step (e) provides values in excess of those from a first operation of step (c).

6. The process of claim 5 wherein said values from a first operation of step (c) are averages of several values.