Description

The invention relates to a method of providing a record carrier having a recording layer with areas having modified optical properties, in which method the recording layer is heated locally by radiation pulses of a write power which is adequate to bring about the change in optical properties.

The invention further relates to a device for providing a record carrier having a recording layer with areas having modified optical properties, which device comprises means for scanning the layer by means of a write beam, means for modulating the power of the radiation beam to obtain radiation pulses having a write power which is adequate to bring about the change in optical properties, and means for adjusting the write power, detection means arranged to detect the proportion in which a property, indicative of the changed optical property, occurs in the radiation originating from the part of the record carrier being scanned.

Such a method and device are known inter alia from US-A- 4,225,873. Said document describes an optical information recording device for recording information in the form of a pattern of areas having modified optical properties in a radiation-sensitive layer of an optical record carrier. In order to verify the pattern thus formed this pattern is read by means of an additional verification beam while the areas are being formed. On the basis of the pattern being read the write power is adapted continually in conformity with a predetermined criterion in order to make the recorded areas largely independent of changing recording conditions, such as for example contaminations of the record-carrier surface or a change in the shape of the scanning spot formed on the radiation-sensitive layer by the write beam. Scanning the radiation-sensitive layer with the additional verification beam poses a problem because it is technically difficult to realise and it involves substantial cost. This applies in particular to recording devices intended for the consumer market because in that case the cost aspect has additional emphasis.

It is an object of the invention to provide a method and a device as defined in the opening paragraphs, by means of which the write power can be adapted continually in a simple manner. As regards the method this object is achieved in accordance with the invention in that a measure of the forming speed with which the areas are formed is determined, the write power being adapted depending upon the measure thus determined. As regards the device this object is achieved in that the device comprises measurement means for deriving from the measurement signal a forming-speed signal which is indicative of the speed with which the areas are formed, and means for adapting the write power depending upon the forming-speed signal.

The invention is based inter alia on the recognition of the fact that the dimensions of the recording areas formed are correlated to the speed with which these areas are formed. By adapting the write power depending on the speed with which the areas are formed the influence of changing recording conditions on the dimensions of the areas can be reduced.

A measure of the speed with which the areas are formed can be obtained very simply in an embodiment of the method which is characterized in that during the formation of the areas a radiation property of the radiation originating from the radiation beam and reflected from or transmitted by the record carrier is detected, which property is indicative of the modified optical properties, the measure of the forming speed being derived on the basis of the proportion in which the radiation property occurs.

A further embodiment of the method is characterized in that the measure of the forming speed is obtained by determining the proportion in which said radiation property occurs in the radiation at instants situated at predetermined time intervals after the starting instants of the radiation pulses, the difference between the proportion thus determined and the proportion in which the property occurs in the instantaneous radiation being integrated in measurement time intervals of constant length situated at predetermined time intervals after the starting instants of the radiation pulses.

Another embodiment of the method is characterized in that the measure of the forming speed is normalised by division by the proportion in which the radiation property occurs in the case of irradiation of a part of the layer in which the optical properties have not yet changed.

This embodiment has the advantage that any variations of the optical properties of the still "uninscribed" layer do not adversely affect the process of determining the forming-speed signal. A very accurate adaptation of the write power setting is obtained in an embodiment of the method which is characterized in that during a calibration procedure areas are formed by means of radiation pulses of different write power, in which areas of optimum shape formed in accordance with a predetermined criterion are selected and in which said measure of the forming speed obtained during the formation of areas of optimum shape is employed as a reference value, the write power during the formation of further areas being adapted depending upon the difference between said reference value and the measure of the forming speed derived during the formation of the further areas. In this method the write power is adapted on the basis of a reference signal value which is optimal for the layer being used.

Moreover, in the case that the recording conditions have changed to such an extent that a reliable formation

of the areas can no longer be guaranteed, the method in accordance with the invention makes it possible to detect this on the basis of the write-power setting. An embodiment of the method which advantageously utilises this property is characterized in that the formation of areas is discontinued if the adapted write power has been larger than or equal to a specific limit value for a period longer than a predetermined time interval.

The invention will now be described in more detail, by way of example, with reference to Figs. 1 to 8, in which

Fig. 1 shows a customary power distribution in the scanning spot obtained when a layer is scanned with a radiation beam,

Fig. 2 gives the variation of the power reflected from the layer during the formation of an area having a reduced reflectivity,

Figs. 3 and 7 show embodiments of the device in accordance with the invention,

Figs. 4a and 4b by way of illustration show the radiation power and a measurement signal derived from the reflected radiation as occurring in the devices shown in Figs. 3 and 7,

Fig. 4c shows an example of a pattern of areas having modified optical properties,

Figs. 5 and 6 show circuits for use in the devices shown in Figs. 3 and 7, and

Fig. 8 is a flow chart of a program performed by a microcomputer in the device shown in Fig. 7.

In a customary method of forming areas having modified optical properties in a layer this layer is scanned by a radiation beam of a pulsating power. Each radiation pulse of suitable write power heats an area of the layer to such a high temperature that this gives rise to an optically detectable change, such as for example a change in reflectivity, a change of structure or a change of the polarity if the magnetisation. Hereinafter, the areas having modified optical properties will be briefly referred to as "effects".

A record carrier suitable for forming the effects may comprise, for example, a substrate with a layer of dye which is subjected to a permanent change of structure upon heating. Alternatively, a layer suitable for forming the effects may comprise a material which upon heating is subjected to a change from a crystalline to an amorphous structure or vice versa, or a magneto-optical material in which the direction of magnetisation is changed in the heated portions of the layer. The effect-forming process is found to be dependent in particular on the distribution of the radiation power in the scanning spot formed on the layer by the radiation beam. Fig. 1 by way of illustration gives the radiation power I per unit area as a function of the distance x from the centre xo of the scanning spot. The power distribution in the scanning spot depends strongly on the recording conditions such as for example the angle at which the beam is incident on the layer. Changes in the optical systems for projecting the radiation beam onto the layer may also affect the power distribution within the scanning spot. Such power distribution variations, which are inevitable in forming the effects have a substantial influence on the dimensions of the effects thus formed. In the case that the radiation beam is aimed at the layer via a transparent substrate a contamination of the substrate surface, for example as a result of fingermarks, also has a substantial influence on the power distribution within the scanning spot and hence on the dimensions of the effects.

It is found that the undesirable influence of changes in the power distribution can be reduced substantially by adapting the write power of the radiation pulse in such a way that the speed with which the effects are formed is maintained substantially constant. During the formation of the effects it is possible to derive a measure for determining said speed from the influence of the effects on the radiation reflected from the layer. For example, if the layer is made of a material whose structure changes under the influence of the heating by the radiation beam the speed with which the area is formed can be derived from the change in the amount of radiation reflected from the layer. When magneto-optical materials are employed this is possible by detecting the change in the direction of polarisation in the reflected radiation beam. For a layer of a material whose structure changes upon irradiation Fig. 2 gives the radiation power P1 reflected from the layer as a function of time in the case that layer is irradiated with a constant-power radiation pulse having a length T. At the beginning of the radiation pulse (t=0) the formation of the effect having a reduced reflectivity has not yet taken place and the reflected radiation power will be high. As a result of the heating caused by the irradiation an expanding effect will be produced so that the reflected power P will decrease at a rate related to the speed with which the effect is formed. A measure of the speed with which the effect is formed may be, for example, the difference ΔP between the reflected power Pio at the beginning of the radiation pulse and the reflected radiation power Pi1 at an instant t1 which is shifted by a predetermined time interval ΔT relative to the beginning of the radiation pulse. An other very suitable measure α' for the speed with which the recording area is formed is given in the following formula.

$$\alpha' = \int_{t2}^{t2+\Delta T2} (Pio-Pi)dt$$

where t2 is an instant at a fixed time interval after the beginning of the radiation pulse;
where ΔT2 is a time interval of constant length, which is wholly situated within the time interval in which the radiation pulse is generated.

The shaded area in Fig. 2 represents the magnitude of the measure α' in the case that t2 coincides with the beginning of the radiation pulse and the length ΔT2 is equal to the pulse duration T.

It is to be noted that the reflectivity of the layer in which no effects have been formed yet (hereinafter referred to as the uninscribed layer) may nevertheless exhibit variations in reflection. These variations lead to an error in determining the measure α' of the effect-forming speed. The influence of these errors can be eliminated by determining a measure of the reflectivity of the uninscribed layer and normalising the measure α' thus determined by division by said measure. The measure of the reflectivity of the uninscribed layer can be determined by setting the power of the radiation beam to a specific low level for which no change in reflection from the layer occurs briefly before the radiation pulse and by selecting the reflected radiation power as a measure of the reflectivity of the uninscribed layer.

Fig. 3 shows an embodiment of a device in accordance with the invention in which the write power is adjusted depending upon a forming-speed signal which is indicative of the speed with which the effects are formed. The reference numeral 2 refers to a disc-shaped record carrier provided with a layer 3 which upon heating above a specific write temperature is subjected to an optically detectable change. Such a record carrier may comprise, for example a transparent substrate 4 on which the layer 3 is deposited. The record carrier is rotated about an axis 6 by means of a customary drive system 5. An optical write head 8 of a customary type is arranged opposite the rotating record carrier 2 to project a radiation beam 7 onto the layer 3. For this purpose such a write head 8 may comprise a radiation source, for example in the form of a laser 9, for generating the radiation beam 7, and a focusing objective 10 for focusing the radiation beam 7 onto the layer 3. A control circuit 13 controls the power of the beam 7 produced by the laser 9 in conformity with a bivalent information signal Vin between a write power Ps proportional to an adjustment signal value Ih and a lower power P1 proportional to an adjustment signal value I1 (see Fig. 4a). The write power Ps is high enough to read the portion of the layer 3 scanned by the beam 7 locally to a temperature above the write temperature. The power P1 is not adequate to heat the layer 3 to a temperature above the write temperature.

Fig. 4a by way of illustration shows the variation of the radiation power P of the radiation beam 7. This Figure shows that the intensity variation is pulse shaped, intervals in which pulses of constant write power Ps are generated alternating with intervals in which the radiation power of the beam is set to the low power P1.

As a result of such a variation of the power P a pattern of effects 41 having modified optical properties is formed in the layer 3 (see Fig. 4c). Since the change produced in the layer 3 concerns optical properties the radiation beam reflected from the layer 3 will exhibit a property which is indicative of the change in optical properties. In the case of layers for which the change in optical properties is a change in reflectivity or a change in structure the power of the reflected beam is indicative of the resulting change in optical properties. In the case that the layer 3 is a magneto-optical layer, in which the direction of magnetisation is locally changed by the radiation pulses, this change manifests itself in the reflected beam as a change in the directions of polarisation of the reflected radiation. For the detection of the property of the reflected beam which is indicative of the change in optical properties the write head 8 comprises a beam-separating element, for example a semi-transparent mirror 10, for directing the reflected radiation beam to a suitable detector system 11. The detector system 11 supplies a signal Vm which represents the proportion in which the property to be detected occurs in the reflected beam. By way of illustration Fig. 4b gives the variation of the signal Vm as a function of time t. In an adjustment circuit 12 a measure of the speed of formation of the effect is derived from the signal Vm and the write power P is adapted in such a way that the measure derived for the speed of effect formation remains substantially constant.

Fig. 5 shows a suitable measurement circuit 50 for determining a measure α of the speed of effect formation in accordance with the following relationship

$$\alpha = \frac{1}{Vmi} \cdot \int_{o}^{T} (Vm(o)-Vm(t))dt$$

where Vm(o) is the value of the measurement signal Vm at the beginning of one of the radiation pulses;
Vm(t) is the instantaneous value of the measurement signal during the radiation pulses,
Vmi represents the value of the measurement signals between the radiation pulses, and
T represents an integration interval contiguous to the beginning of the radiation pulses.

In Fig. 4 the dimensions of the shaded areas are indicative of the value of α.

To determine the values Vm(o) and Vmi the measurement circuit 50 comprises a first sample and hold circuit 51 and a second sample and hold circuit 52, to which the measurement signal Vm is applied. In a customary manner a control circuit 53 derives from the signal Vin control signals for the sample and hold circuits 51 and 52, in such a way the sample and hold circuit 51 each time samples the measurement signal at the beginning of the radiation pulses and holds the value until the next sampling instant and the sample and hold circuit 52 samples the value of Vm between every two radiation pulses, for example at a fixed instant after the end of the radiation pulses, and holds this value until the next sampling operation.

The sample and hold circuit 51 has its output coupled to a control input of a current source 54 which supplies a current to a capacitor 55. The current source 54 is of a type supplying a current whose value is proportional to the signal value on the control input. The measurement signal Vm is further applied to a second current source 56, which draws a current from the capacitor 55 whose value is proportional to the measurement signal Vm. A third sample and hold circuit 57 has an input connected to the capacitor 55. The sample and hold circuit 57 is controlled by the control circuit 53 in such a way that at the instant shifted by a time interval T (inclusive T=0) relative to the starting instant of the radiation pulse the voltage across the capacitor 55 is sampled and is held until the next sampling interval. In the time interval between the sampling operation performed by the sample and hold circuit 57 and the beginning of the next radiation pulse the capacitor 55 is short-circuited by a switch 58 controlled by a control circuit 53. In this way the integral of the difference between the measurement signal Vm(o) on the output of the sample and hold circuit 51 and the instantaneous value of the measurement signal Vm is constantly available on the output of the sample and hold circuit 57. This integral is a measure of the speed with which the effects are formed. The signal on the output of the sample and hold circuit 57 can be used directly as a measure of the speed of the effect formation. However, in order to reduce variations in the signal Vm resulting from variations in optical properties of the layer 3 which are not related to the effect-forming speed, it is preferred to normalise the integral value available on the output of the sample and hold circuit 57 by dividing this integral value by the output signal of the sample and hold circuit 52. For this purpose the circuit 50 comprises a dividing circuit 59. The normalised signal on the output of the dividing circuit 59 will be referred to hereinafter as the normalised forming-speed signal $\alpha(t)$.

It is to be noted that for determining the forming-speed signal $\alpha(t)$ it is not necessary that the integration interval is contiguous to the beginnings of the radiation pulses. Alternatively the integration interval may be shifted relative to the beginning by a fixed time interval. However, since the variations of the signal Vm are maximal immediately after the beginning of the radiation pulse it is preferred to have an integration interval which is contiguous with the beginning of the radiation pulse.

Moreover, it is to be noted that for determining a signal which is indicative of the effect-forming speed it is not necessary to integrate the measurement signal Vm. In principle, the rate at which the measurement signal changes and hence the effect-forming speed can also be determined in a different way. This is possible, for example, by determining the difference in the measurement signal between two predetermined instants after the beginning of a radiation pulse. Moreover, it is to be noted that the length of the radiation pulse does not influence the effect-forming speed at the beginning of the radiation pulse, so that comparable measures of the effect-forming speed are obtained for radiation pulses of different length as occur normally in information signal recording .

The embodiment described above applies to a so-called "black-recording" layer for which the amount of reflected radiation decreases as a result of the effect. However, the invention can also be applied to a "white-recording" layer for which the amount of reflected radiation increases as a result of the effect.

Fig. 6 shows a circuit 60 for adapting the write power of the radiation beam 7 depending upon the forming-speed signal $\alpha(t)$. In this Figure elements corresponding to those in the Figures described above bear the same reference numerals. In the circuit 60 a differential stage 61 determines the difference between the forming-speed signal $\alpha(t)$ and a reference signal $\alpha 0$. The difference thus determined is applied to a customary control circuit, for example one comprising an integration stage 62. The integration stage 62 is of a type which supplies

an output signal whose signal value is a time integral of the signal applied to the integration stage 62. The output signal Δi of the integration stage is applied to an adder stage 64, if necessary via a signal-limiter stage 63. The adder stage 64 also receives a signal of a signal value Iho which is indicative of a nominal setting of the write power Ps of the radiation beam 7. The adder stage 64 supplies an output signal with the integral value Ih for adapting the desired write power Ps. The circuit 60 operates as follows. The nominal value of the write power R represented by the adjustment signal value Iho is selected in such a way that the dimensions of the resulting effects is optimum under optimum write conditions. The reference signal αo then represents the corresponding effect forming speed. If the recording conditions change the effects will not have optimum dimensions at the nominal write power. As a result of this, there will be a deviation between the reference signal αo and the forming-speed signal α(t). This results in a change of the output signal Δi of the integration stage 62 and hence an adaptation of the write power Ps. In this way the write power is constantly adapted in such a way that the difference between the forming-speed signal α(t) and the reference signal αo remains minimal. Since the dimensions of the areas are closely correlated to the effect-forming speed the adaptations will ensure that the dimensions of the areas remain substantially optimal in the case of changing recording conditions.

As already stated hereinbefore the output signal of the integration stage 62 may be applied to the adder circuit via a limiter stage 63. The signal limiter signal stage 63 is of a customary type which limits the signal passed through this stage at a specific limit value if the applied signal exceeds this limit value. The use of the signal limiter circuit 63 is particularly advantageous in the case that the recording conditions can change so drastically that compensation through adaptation of the write power Ps is no longer possible. In that case the use of the signal limiter stage 63 prevents the write power setting Ps from becoming so large that the laser 9 or the record carrier 2 may be damaged. When the input signal exceeds the limit value for a longer period this also indicates that the recording conditions have changed so drastically that the formation of the areas can no longer be regarded as reliable. Therefore, it is to be preferred to discontinue the formation of areas in such a case. This is possible, for example, by means of a monitoring signal from the signal limiter stage 63, which signal indicates that the input signal has exceeded the limit value for a period longer than a predetermined time interval and which together with the information signal Vi is applied to a gate circuit, for example an AND gate 65, which may interrupt the transfer of the information signal Vi depending on the monitoring signal.

It is to be noted that the location of the signal limiter stage 63 in Fig. 6 is not limited to the location shown but that it may also be arranged between the adder stage 64 and the stage 13. As regards the generation of the monitoring signal, which indicates whether the desired write power setting has been larger than or equal to a specific limit value for a time longer than a predetermined time interval, it will be obvious to those skilled in the art that this can be realised in numerous ways. The reference signal αo and the adjustment-signal value Iho which indicate the nominal write power may be fixed values. However, if very stringent requirements are imposed on the accuracy of the write power setting, it is preferred to determine at least the reference value αo in a separate calibration procedure prior to the actual recording of the effects pattern. During such a calibration procedure a test pattern of effects is formed for different settings of the write power and on the basis of the test patterns thus formed the forming-speed signal α belonging to the pattern having optimum dimensions is selected as the reference signal α0. Devices for determining the patterns of effects having optimum dimensions are described inter alia in NL-A-8901591 and NL-A-8901345, for forming a pattern of effects having modified optical properties by optical and by magnetic means respectively. Both Patent Applications NL-A-8901591 and NL-A-8901345 are incorporated herewith by reference. In the calibration procedure, described in the aforementioned Patent Specifications, a test information pattern is recorded at an addressable location in a track on the record carrier at different write powers Ps. Subsequently, these test information patterns are read and on the basis of the information thus read test information patterns having the optimum write intensity are selected and the reference signal αo is adapted to the forming-speed signal α corresponding to the test information pattern thus selected. An embodiment of a recording device in which the adjustment-signal value Iho and the reference signal αo are determined in a calibration procedure is shown in Fig. 7. The recording device shown comprises drive means in the form of a motor 100 and a turntable 101 for rotating a radiation sensitive record carrier 4' about an axis 102, which record carrier is of a type on which address information is recorded in the form of a track modulation of a servotrack. Such a record carrier 4' is described in detail in Netherlands Patent Applications NL-A-8800151, NL-A-8900766, and NL-A-89001145, herewith incorporated by reference. The record carrier described in said Patent Applications have a wobbling servotrack in which the frequency of the wobble is modulated in conformity with a position-information signal which includes address codes ATIP. An optical read/write head 105 of a customary type is arranged opposite the rotating record carrier 4' and can be moved in a radial direction relative to the record carrier 4' by means of a positioning device, for example comprising a motor 103 and a spindle 104. If desired, the read/write head 105 can be employed both for forming information patterns and for reading information patterns. For this purpose the read/write head 105 comprises a semiconductor laser for generating a radiation beam 107a with a radiation power which is adjust-

able by means of a driver circuit 107. The radiation beam 107a is aimed at the servotrack of the record carrier 4' in known manner. The beam 107a is then partly reflected from the record carrier 4', the reflected beam being modulated in conformity with the track wobble and, if an information pattern is present, also in conformity with the information pattern. The reflected beam is directed to a radiation sensitive detector 108a, which generates a read signal V1" corresponding to the beam modulation. The signal V1" comprises a component which is produced by the track wobble and which has a frequency which is approximately 22 kHz at the nominal scanning speed. By means of a motor control circuit 108 for controlling the motor 100 the speed of the motor is controlled in such a manner that the frequency of the component produced by the track wobble in the read signal V1" is maintained substantially equal to 22 kHz. The read signal V1" is also applied to a detection circuit 109 which derives address codes ATIP from the track wobble component in the read signal V1" and applies them to a control unit comprising, for example, a microcomputer 110. In addition, the read signal V1" is applied to an amplifier circuit 111 having a high-pass characteristic to eliminate the signal components produced in the read signal V1" by the track wobble. The read signal V1' whose low-frequency components have thus been removed is applied to the analysis circuit 65, which is for example of a type described comprehensively in the afore-mentioned Patent Application NL-A 8901591. An analysis signal Va on the output of the analysis circuit 65 indicates the extent to which the pattern deviates from the optimum pattern and is also applied to the microcomputer 110. The recording device further comprises a customary CIRC encoding circuit 112, to which the signal Vi to be recorded can be applied via a switch 115 controlled by the microcomputer 110. The CIRC encoding circuit 112 is arranged in series with an EFM modulator 113. The output of the EFM modulator 113 is connected to the driver circuit 107. The driver circuit 107 is of a controllable type which, for receiving control signals, is coupled to the microcomputer 110. Depending on the control signals received from the microcomputer 110 the driver circuit 107 sets the intensity of the generated radiation beam 107a to a constant low power P1 or the driver circuit 107 sets the power of the radiation beam in conformity with the EFM modulated signal received from the EFM modulator 113 between the low power P1 and the write power Ps. Moreover, the write power Ps can be adjusted by the microcomputer 110. For the purpose of generating a test information pattern the recording device shown in Fig. 7 comprises a signal generator 114, which generates for example a random digital signal or which generates a signal corresponding to the analog signal value zero (digital silence). Preferably, the test information patterns are formed at addressable locations in the servotrack of the record carrier 4'. If the format of the record carrier 4' is as described in the afore-mentioned Netherlands Patent Application NL-A-8900766, in which the servotrack is divided, in this sequence, into an area (PMA) for recording a temporary table of contents (Temporary TOC), an area (Lead In Area) for the storage of the definitive table of contents (TOC), and a program area (Program Area), the test information patterns are preferably recorded in an area (PCA) preceding the area (PMA) for recording the temporary table of contents.

The microcomputer 110 is loaded with a suitable control program for causing the process of determining the nominal value Iho and the reference signal αo to be carried out. The flow chart of an example of such a program is given in Fig. 8. In a step S1 the address of the track portion to be used for recording the test information pattern is determined. In the step S2 the track portion having said address is located under control of the microcomputer 110. Once this area is reached the write level Ps is set to an initial value Po in a step S3. The value of Po for the relevant record carrier is suitably prerecorded on the record carrier in a manner as set forth in the afore-mentioned Patent Application NL-A-8901145. This value can then be read prior to the adjustment cycle. Moreover, under control of the microcomputer 110 the signal generator 114 is connected to the CIRC encoder circuit 112 by means of the controllable switch 115, so that an EFM modulated test signal determined by the output signal of the signal generator is generated by the EFM modulator 113. Finally, in a step S4 the driver circdit 107 is set by means of the control signal L/S in such a way that the power of the radiation beam 107a is switched, in conformity with the EFM modulated signal Vefm on the output of the EFM modulator 113, between the selected value of the write power Ps and the power P1, which results in a test information pattern corresponding to an EFM signal being recorded. Moreover, in the step S4 the corresponding forming-speed signal $\alpha(t)$ is determined by the measurement circuit 50, and together with the read signal Ih corresponding to the power setting pl it is stored in the microcomputer 110. In a step S5 the address code ATIP detected by the detection circuit 109 is read by the computer 110. In a step S6 it is ascertained whether this address code has changed in comparison with the previous read out. If this is not the case the step S5 is repeated. If it has changed it is checked in a step S7 whether the absolute time code read indicates the end of the track portion intended for recording the test patterns. If this is not the case a step S8 is carried out, in which the write power Ps is incremented by a small step ΔS by adapting the adjustment signal value ih, after which the program proceeds with the step S5. If in the step S7 it is found that the end of the track portion intended for recording is reached a step S9 is carried out, in which the driver circuit 107 is set in such a way by means of the control signal L/S that the power of the radiation beam 107a is maintained constant at the low power level P1. In a step S10 the beginning of the track portion provided with the test pattern is located and read. In a

step S11 the analysis signal Va is read by the microcomputer 110. In a step S12 it is checked whether the value of the analysis signal Va corresponds to the optimum write power Ps. If this is not the case, the program proceeds with the step S11. In the case of correspondence the address code detected by the detection circuit 109 is read in the step S13. Subsequently, in a step S14 the adjustment signal value Ih and the forming-speed signal $\alpha(t)$ stored in the microcomputer together with the said address are read out again and the reference signal $\alpha(t)$ and the adjustment signal value Iho are adjusted in conformity with the information thus read. Subsequently, during the formation of the pattern of areas corresponding to the signal Vi the write power can then be adapted again on the basis of the difference between the reference signal αo thus determined and the instantaneous forming-speed signal $\alpha(t)$ on the output of the measurement circuit 50. For this purpose the microcomputer is loaded with a suitable program which, by adaptation of the adjustment signal value Ih, constantly adapts the write power Ps so as to minimize the difference between the forming-speed signal $\alpha(t)$ and the reference signal αo.

It is to be noted that in the example of the calibration procedure described above the method of determining the pattern having optimal deviations is only one of the numerous methods which are possible. For other methods of determining this pattern reference is made to the aforementioned Patent Applications NL-A-8905191 and NL-A-8901345. It is essential only that the associated forming-speed signal α is then used as the reference signal $\alpha 0$.

Claims

1. A method of providing a record carrier having a recording layer with areas having modified optical properties,in which method the recording layer is heated locally by radiation pulses of a write power which is adequate to bring about the change in optical properties, characterized in that a measure of the forming speed with which the areas are formed is determined, the write power being adapted depending upon the measure thus determined.

2. A method as claimed in Claim 1, characterized in that during the formation of the areas a radiation property of the radiation originating from the radiation beam and reflected from or transmitted by the record carrier is detected, which property is indicative of the modified optical properties, the measure of the forming speed being derived on the basis of the proportion in which the radiation property occurs.

3. A method as claimed in Claim 2, characterized in that the measure of the forming speed is obtained by determining the proportion in which said radiation property occurs in the radiation at instants situated at predetermined time intervals after the starting instants of the radiation pulses, the difference between the proportion thus determined and the proportion in which said property occurs in the instantaneous radiation being integrated in measurement time intervals of constant length situated at predetermined time intervals after the starting instants of the radiation pulses.

4. A method as claimed in Claim 2 or 3, characterized in that the measure of the forming speed is normalised by division by the proportion in which the radiation property occurs in the case of irradiation of a part of the layer in which the optical properties have not yet changed.

5. A method as claimed in any one of the preceding Claims, in which during a calibration procedure areas are formed by means of radiation pulses of different write power, in which areas of optimum shape formed in accordance with a predetermined criterion are selected and in which said measure of the forming speed obtained during the formation of areas of optimum shape is employed as a reference value, the write power during the formation of further areas being adapted depending upon the difference between said reference value and the measure of the forming speed derived during the formation of the further areas.

6. A method as claimed in any one of the preceding Claims, characterized in that the formation of areas is discontinued if the adapted write power has been larger than or equal to a specific limit value for a time longer than a predetermined time interval.

7. A device for providing a record carrier (4) having a recording layer (3) with areas having modified optical properties, which device comprises means (8, 105) for scanning the layer by means of a write beam (7, 107a), means for modulating the power of the radiation beam to obtain radiation pulses having a write power which is adequate to bring about the change in optical properties, and means (12, 107) for adjusting the write power, detection means (11, 108a) arranged to detect the proportion in which a property, indi-

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step S11 the analysis signal Va is read by the microcomputer 110. In a step S12 it is checked whether the value of the analysis signal Va corresponds to the optimum write power Ps. If this is not the case, the program proceeds with the step S11. In the case of correspondence the address code detected by the detection circuit 109 is read in the step S13. Subsequently, in a step S14 the adjustment signal value ih and the forming-speed signal $\alpha(t)$ stored in the microcomputer together with the said address are read out again and the reference signal $\alpha(t)$ and the adjustment signal value Iho are adjusted in conformity with the information thus read. Subsequently, during the formation of the pattern of areas corresponding to the signal Vi the write power can then be adapted again on the basis of the difference between the reference signal αo thus determined and the instantaneous forming-speed signal $\alpha(t)$ on the output of the measurement circuit 50. For this purpose the microcomputer is loaded with a suitable program which, by adaptation of the adjustment signal value Ih, constantly adapts the write power Ps so as to minimize the difference between the forming-speed signal $\alpha(t)$ and the reference signal αo.

It is to be noted that in the example of the calibration procedure described above the method of determining the pattern having optimal deviations is only one of the numerous methods which are possible. For other methods of determining this pattern reference is made to the aforementioned Patent Applications NL-A-8905191 and NL-A-8901345. It is essential only that the associated forming-speed signal α is then used as the reference signal $\alpha 0$.

Claims

1. A method of providing a record carrier having a recording layer with areas having modified optical properties,in which method the recording layer is heated locally by radiation pulses of a write power which is adequate to bring about the change in optical properties, characterized in that a measure of the forming speed with which the areas are formed is determined, the write power being adapted depending upon the measure thus determined.

2. A method as claimed in Claim 1, characterized in that during the formation of the areas a radiation property of the radiation originating from the radiation beam and reflected from or transmitted by the record carrier is detected, which property is indicative of the modified optical properties, the measure of the forming speed being derived on the basis of the proportion in which the radiation property occurs.

3. A method as claimed in Claim 2, characterized in that the measure of the forming speed is obtained by determining the proportion in which said radiation property occurs in the radiation at instants situated at predetermined time intervals after the starting instants of the radiation pulses, the difference between the proportion thus determined and the proportion in which said property occurs in the instantaneous radiation being integrated in measurement time intervals of constant length situated at predetermined time intervals after the starting instants of the radiation pulses.

4. A method as claimed in Claim 2 or 3, characterized in that the measure of the forming speed is normalised by division by the proportion in which the radiation property occurs in the case of irradiation of a part of the layer in which the optical properties have not yet changed.

5. A method as claimed in any one of the preceding Claims, in which during a calibration procedure areas are formed by means of radiation pulses of different write power, in which areas of optimum shape formed in accordance with a predetermined criterion are selected and in which said measure of the forming speed obtained during the formation of areas of optimum shape is employed as a reference value, the write power during the formation of further areas being adapted depending upon the difference between said reference value and the measure of the forming speed derived during the formation of the further areas.

6. A method as claimed in any one of the preceding Claims, characterized in that the formation of areas is discontinued if the adapted write power has been larger than or equal to a specific limit value for a time longer than a predetermined time interval.

7. A device for providing a record carrier (4) having a recording layer (3) with areas having modified optical properties, which device comprises means (8, 105) for scanning the layer by means of a write beam (7, 107a), means for modulating the power of the radiation beam to obtain radiation pulses having a write power which is adequate to bring about the change in optical properties, and means (12, 107) for adjusting the write power, detection means (11, 108a) arranged to detect the proportion in which a property, indi-

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cative of the changed optical property, occurs in the radiation originating from the part of the record carrier (4) being scanned, characterized in that the device comprises measurement means (50, 60) for deriving from the measurement signal a forming-speed signal which is indicative of the speed with which the areas are formed, and means (107) for adapting the write power depending upon the forming-speed signal.

8. A device as claimed in Claim 7, characterized in that for determining the forming-speed signal the measurement means (50, 60) comprise sample and hold means (51) for sampling the measurement signal at sampling instants situated at predetermined instants relative to the starting instants of the radiation pulses, integration means (62) for integrating during measurement intervals of predetermined length the difference between the instantaneous value and the sample value of the measurement signal, which measurement intervals are situated at predetermined positions relative to the starting instants of the radiation pulses.

9. A device as claimed in Claim 8, characterized in that for obtaining a normalisation value the measurement means (50, 60) comprise second sample and hold means (52) for sampling the measurement signal at second sampling instants situated between the time intervals in which the radiation pulses are generated, and means (59) for normalising the forming-speed signal by division by the sampled value determined by the second sample and hold means (52).

10. A device as claimed in Claim 7, 8 and 9, characterized in that the device comprises monitoring means (63) for generating a monitoring signal if the adjusted write power has been equal to or higher than a specific limit value for a time longer than a predetermined time interval.

11. A device as claimed in Claim 10, characterized in that the device comprises means (65) responsive to the monitoring signal to discontinue the formation of the pattern of areas.

12. A device as claimed in any one of the Claims 7, 8, 9, 10 or 11, characterized in that the device comprises control means for causing during a calibration interval areas to be formed by means (110) of radiation pulses having different write powers, means for selecting areas of optimum dimensions in conformity with a specific criterion, the control means (110) being further adapted, for the purpose of determining a reference signal, to cause the forming-speed signal to be determined during the formation of the selected areas of optimum dimensions, the adaptation means being constructed to adapt the write power, in a period following the time interval, depending upon the difference between said reference signal and the instantaneous forming-speed signal.

Patentansprüche

1. Verfahren, um einen Aufzeichnungsträger, der eine Aufzeichnungsschicht hat, mit Gebieten mit geänderten optischen Eigenschaften zu versehen, in welchem Verfahren die Aufzeichnungsschicht durch Strahlungsimpulse mit einer für die Bewirkung der Änderung der optischen Eigenschaften geeigneten Schreibleistung lokal erwärmt wird, dadurch gekennzeichnet, daß ein Maß für die Bildungsgeschwindigkeit, bei der die Gebiete gebildet werden, festgelegt wird, wobei die Schreibleistung von dem so festgelegten Maß abhängig ist.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß während der Bildung der Gebiete eine Strahlungseigenschaft der aus dem Strahlenbündel stammenden und an dem Aufzeichnungsträger reflektierten oder von ihm durchgelassenen Strahlung detektiert wird, welche Eigenschaft die geänderten optischen Eigenschaften anzeigt, wobei das Maß für die Bildungsgeschwindigkeit auf der Grundlage des Anteils abgeleitet wird, in dem die Strahlungseigenschaft auftritt.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß das Maß für die Bildungsgeschwindigkeit durch Bestimmung des Anteils, in dem die genannte Strahlungseigenschaft in der Strahlung zu Zeitpunkten auftritt, die bei vorbestimmten Zeitintervallen nach den Anfangszeitpunkten der Strahlungsimpulse liegen, erhalten wird, wobei der Unterschied zwischen dem so bestimmten Anteil und dem Anteil, in dem die genannte Eigenschaft in der momentanen Strahlung auftritt, in Meßzeitintervallen konstanter Länge integriert wird, die bei vorbestimmten Zeitintervallen nach den Anfangszeitpunkten der Strahlungsimpulse liegen.

4. Verfahren nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß das Maß für die Bildungsgeschwindigkeit durch Division durch den Anteil normiert wird, in dem die Strahlungseigenschaft bei Bestrahlung eines Teils der Schicht auftritt, in welchem die optischen Eigenschaften sich noch nicht geändert haben.

5. Verfahren nach einem der vorhergehenden Ansprüche, bei dem während eines Kalibrierungsprozesses mit Hilfe von Strahlungsimpulsen unterschiedlicher Schreibleistung Gebiete gebildet werden, wobei entsprechend einem vorbestimmten Kriterium gebildete Gebiete mit optimaler Form selektiert werden und wobei das genannte, bei der Bildung der Gebiete mit optimaler Form erhaltene Maß für die Bildungsgeschwindigkeit als Bezugswert verwendet wird, wobei die Schreibleistung während der Bildung der weiteren Gebiete in Abhängigkeit von der Differenz zwischen dem genannten Bezugswert und dem genannten Maß für die Bildungsgeschwindigkeit während der Bildung der weiteren Gebiete angepaßt wird.

6. Verfahren nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Bildung der Gebiete nicht fortgesetzt wird, wenn die angepaßte Schreibleistung längere Zeit als ein zuvor bestimmtes Zeitintervall größer oder gleich einem bestimmten Grenzwert ist.

7. Einrichtung, um einen Aufzeichnungsträger (4), der eine Aufzeichnungsschicht (3) hat, mit Gebieten mit geänderten optischen Eigenschaften zu versehen, wobei die Einrichtung Mittel (8, 105) zum Abtasten der Schicht mit Hilfe eines Schreibstrahlenbündels (7, 107a) umfaßt sowie Mittel zum Modulieren der Leistung des Strahlenbündels, um Strahlungsimpulse mit einer Schreibleistung zu erhalten, die für die Bewirkung der Änderung der optischen Eigenschaften ausreicht, und Mittel (12, 107) zum Einstellen der Schreibleistung, Detektionsmittel (11, 108a) zum Detektieren des Verhältnisses, in dem eine die geänderte optische Eigenschaft anzeigende Eigenschaft in der von dem abgetasteten Teil des Aufzeichnungsträgers (4) kommenden Strahlung auftritt, dadurch gekennzeichnet, daß die Einrichtung Meßmittel (50, 60) umfaßt, um aus dem Meßsignal ein die Geschwindigkeit, mit der die Gebiete gebildet werden, anzeigendes Bildungsgeschwindigkeitssignal abzuleiten, und Mittel (107) zum Anpassen der Schreibleistung in Abhängigkeit von dem Bildungsgeschwindigkeitssignal.

8. Einrichtung nach Anspruch 7, dadurch gekennzeichnet, daß zur Bestimmung des Bildungsgeschwindigkeitssignals die Meßmittel (50, 60) Abtast- und Halte-Mittel (51) umfassen, um das Meßsignal zu auf vorbestimmten Zeitpunkten relativ zu den Anfangszeitpunkten der Strahlungsimpulse liegenden Abtastzeitpunkten abzutasten, sowie Integrationsmittel (62) zum Integrieren der Differenz zwischen dem Momentanwert und dem Abtastwert des Meßsignals während Meßintervallen vorbestimmter Länge, wobei diese Meßintervalle an vorbestimmten Stellen relativ zu den Anfangszeitpunkten der Strahlungsimpulse liegen.

9. Einrichtung nach Anspruch 8, dadurch gekennzeichnet, daß zum Erhalten eines Normierungswertes die Meßmittel (50, 60) zweite Abtast- und Halte-Mittel (52) umfassen, um das Meßsignal zu zwischen den Zeitintervallen, in denen die Strahlungsimpulse generiert werden, liegenden zweiten Abtastzeitpunkten abzutasten, sowie Mittel (59) zum Normieren des Bildungsgeschwindigkeitssignals durch Division durch den von den zweiten Abtast- und Halte-Mittel (52) bestimmten Abtastwert.

10. Einrichtung nach Anspruch 7, 8 und 9, dadurch gekennzeichnet, daß die Einrichtung Überwachungsmittel (63) zur Generierung eines Überwachungssignals umfaßt, wenn die eingestellte Schreibleistung längere Zeit als ein zuvor bestimmtes Zeitintervall gleich oder größer als ein bestimmter Grenzwert ist.

11. Einrichtung nach Anspruch 7, dadurch gekennzeichnet, daß die Einrichtung Mittel (65) umfaßt, um in Reaktion auf das Überwachungssignal die Bildung des Musters aus Gebieten nicht fortzusetzen.

12. Einrichtung nach einem der Ansprüche 7, 8, 9, 10 oder 11, dadurch gekennzeichnet, daß die Einrichtung Steuerungsmittel (110) umfaßt, damit während eines Kalibrierungsintervalls mit Hilfe von Strahlungsimpulsen mit unterschiedlichen Schreibleistungen Gebiete gebildet werden, Mittel zum Selektieren von Gebieten optimaler Abmessungen entsprechend einem bestimmten Kriterium, wobei die Steuerungsmittel (110) weiterhin eingerichtet sind, zur Bestimmung eines Bezugssignals dafür zu sorgen, daß das Bildungsgeschwindigkeitssignal während der Bildung der selektierten Gebiete optimaler Abmessungen bestimmt wird, wobei die Anpassungsmittel so ausgeführt sind, daß die Schreibleistung in einer dem Zeitintervall folgenden Periode angepaßt wird, in Abhängigkeit von der Differenz zwischen dem genannten Bezugssignal und dem momentanen Bildungsgeschwindigkeitssignal.

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Revendications

1. Procédé pour former un support d'enregistrement présentant une couche d'enregistrement munie de domaines présentant des propriétés optiques modifiées, selon lequel la couche d'enregistrement est chauffée localement par des impulsions de rayonnement d'une puissance d'écriture qui est appropriée à provoquer le changement en propriétés optiques, caractérisé en ce qu'une mesure de la vitesse de formation avec laquelle les domaines sont formés est déterminée, la puissance d'écriture étant adaptée en fonction de la mesure ainsi déterminée.

2. Procédé selon la revendication 1, caractérisé en ce que lors de la formation des domaines une propriété de rayonnement du rayonnement provenant du faisceau de rayonnement et réfléchi ou transmis par le support d'enregistrement est détectée, laquelle propriété est indicative des propriétés optiques modifiées, la mesure de la vitesse de formation étant dérivée à base de la proportion dans laquelle se produit la propriété de rayonnement.

3. Procédé selon la revendication 2, caractérisé en ce que la mesure de la vitesse de formation s'obtient par détermination de la proportion dans laquelle se produit ladite propriété de rayonnement dans le rayonnement aux moments situés à des intervalles de temps prédéterminés après les moments de démarrage des impulsions de rayonnement, la différence entre la proportion ainsi déterminée et la proportion dans laquelle se produit ladite propriété dans le rayonnement instantané étant intégrée dans des intervalles de temps de mesure de longueur constante situés à des intervalles de temps prédéterminés après les moments de démarrage des impulsions de rayonnement.

4. Procédé selon la revendication 2 ou 3, caractérisé en ce que la mesure de la vitesse de formation est normalisée par division par la proportion dans laquelle se produit la propriété de rayonnement dans le cas d'irradiation d'une partie de la couche dans laquelle les propriétés optiques n'ont pas encore subi de changement.

5. Procédé selon l'une des revendications précédentes dans lequel, lors d'un processus de calibrage, des domaines sont formés à l'aide d'impulsions de rayonnement de puissance d'écriture différente, selon lequel des domaines de forme optimale conformes à un critère prédéterminé sont sélectionnés et selon lequel ladite mesure de la vitesse de formation obtenue pendant la formation de domaines de forme optimale est utilisée comme une valeur de référence, la puissance d'écriture pendant la formation d'autres domaines étant adaptée en fonction de la différence entre ladite valeur de référence et la mesure de la vitesse de formation dérivée pendant la formation des autres domaines.

6. Procédé selon l'une des revendications précédentes, caractérisé en ce que la formation de domaines est interrompue lorsque la puissance d'écriture adaptée a été supérieure ou égale à une valeur limite spécifique pendant un temps supérieur à un intervalle de temps prédéterminé.

7. Dispositif pour fournir un support d'enregistrement (4) présentant une couche d'enregistrement (3) munie de domaines présentant des propriétés optiques modifiées, lequel dispositif est muni de moyens (8,105) pour le balayage de la couche à l'aide d'un faisceau d'écriture (7,107a) de moyens pour moduler la puissance du faisceau de rayonnement afin d'obtenir des impulsions de rayonnement présentant une puissance d'écriture qui est appropriée à provoquer le changement en propriétés optiques, et de moyens (12,107) pour régler la puissance d'écriture, de moyens de détection (11,108a) disposés pour détecter la proportion dans laquelle se produit une propriété, indicative de la propriété optique changée, dans le rayonnement provenant de la partie du support d'enregistrement (4) en balayage, caractérisé en ce que le dispositif est muni de moyens de mesure (50,60) pour dériver du signal de mesure un signal de vitesse de formation qui est indicative de la vitesse avec laquelle se forment les domaines, et de moyens (107) pour adapter la puissance d'écriture en fonction du signal de vitesse de formation.

8. Dispositif selon la revendication (7), caractérisé en ce que pour déterminer le signal de vitesse de formation, les moyens de mesure (50,60) sont munis de moyens d'échantillonnage et de maintien (51) pour échantillonner le signal de mesure au moment d'échantillonnage situé à des moments prédéterminés par rapport aux moments de démarrage des impulsions de rayonnement, de moyens d'intégration (62) pour intégrer, pendant des intervalles de mesure de longueur prédéterminés, la différence entre la valeur instantanée et la valeur échantillonnée du signal de mesure, lesquels intervalles sont situés à des positions prédéterminées par rapport aux moments de démarrage des impulsions de rayonnement.

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9. Dispositif selon la revendication 8, caractérisé en ce que pour obtenir une valeur de normalisation, les moyens de mesure (50,60) sont munis de deuxièmes moyens d'échantillonnage et de maintien (52) pour échantillonner le signal de mesure à des deuxièmes moments d'échantillonnage situés entre les intervalles de temps dans lesquels sont engendrées les impulsions de rayonnement, et de moyens (59) pour normaliser le signal de vitesse de formation par division par la valeur échantillonnée déterminée par les deuxièmes moyens d'échantillonnage et de maintien (52).

10. Dispositif selon la revendication 7, 8 et 9, caractérisé en ce que le dispositif est muni de moyens de contrôle (63) pour engendrer un signal de contrôle lorsque la puissance d'écriture établie a été égale ou supérieure à une valeur limite spécifique pour un temps supérieur à un intervalle de temps prédéterminé.

11. Dispositif selon la revendication 10, caractérisé en ce que le dispositif est muni de moyens (65) sensibles au signal de contrôle pour interrompre la formation de la configuration de domaines.

12. Dispositif selon l'une des revendications 7, 8, 9, 10 ou 11, caractérisé en ce que le dispositif est muni de moyens de commande (110) pour provoquer, pendant un intervalle de calibrage, la formation de domaines à l'aide d'impulsions de rayonnement présentant de différentes puissances d'écriture, de moyens pour sélectionner des domaines de dimensions optimales conformément à un critère spécifique, les moyens de commande (110) étant en outre adaptés, dans le but de déterminer un signal de référence, à provoquer le signal de vitesse de formation à déterminer pendant la formation des domaines sélectionnés de dimensions optimales, les moyens d'adaptation étant conçus pour adapter la puissance d'écriture, dans une période suivant l'intervalle de temps, en fonction de la différence entre ledit signal de référence et le signal de vitesse de formation instantané.