(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 098 343**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **83101764.5**

(22) Date of filing: **23.02.83**

(51) Int. Cl.³: **C 22 F 3/00**

(30) Priority: **29.06.82 US 393255**

(43) Date of publication of application: **18.01.84**
Bulletin 84/3

(84) Designated Contracting States: **DE FR GB**

(71) Applicant: **International Business Machines Corporation, Old Orchard Road, Armonk, N.Y. 10504 (US)**

(72) Inventor: **Lin, Flossie Li-Sheng, 714 Colleen Drive, San Jose California 95123 (US)**

(74) Representative: **Hobbs, Francis John, IBM United Kingdom Patent Operations Hursley Park, Winchester Hants, SO21 2JN (GB)**

(54) Laser annealing of metallic alloy substrates.

(57) A smooth homogeneous surface is provided on an aluminium alloy disk substrate by rotating the substrate, heating the rotating substrate with a laser beam to melt a portion of the upper surface, including any second phase defects, and polishing the melted surface after it has solidified.

EP 0 098 343 A2

LASER ANNEALING OF METALLIC ALLOY SUBSTRATES

This invention relates to a method of improving the microstructure homogeneity of a metallic alloy disk substrate having second phase defects on the surface thereof.

While the metallurgical art is crowded with methods for modifying the surface properties of metal articles, most of these do not involve melting, but are solid state transformations. Although the laser has been used in the field of metallurgy since soon after its invention, the vast majority of laser metal treating operations involve either no melting, as in the transformation hardening of steel, or extremely deep melting as in welding and cutting.

The technique shown as shock hardening uses extremely high power densities and short interaction times to produce a metal vapour cloud which leaves the metal surface with a high enough velocity to create a shock wave at the metal surface. Hole drilling uses a laser to produce holes in materials by vapourization of the substrate by the laser beam. Deep penetration welding uses a moderate power density and a moderate interaction time to produce deep melting in metal articles to be joined. The melting is usually accompanied by the formation of a hollow cavity which is filled with plasma and metal vapour. Finally, transformation hardening is performed at low power densities and long interaction times.

Shock hardening and hole drilling are usually performed using pulsed lasers since pulsed lasers are the most reasonable way to achieve the desired combination of power density and interaction time. Deep penetration welding and transformation hardening are usually performed using a continuous laser and the interaction time is controlled by sweeping the laser beam over the area to be welded or hardened. The region of the present invention is shown as "skin melting". This region is bounded on one side by conditions where surface vapourization will occur and on the other side by conditions where surface melting will occur. Transformation hardening is performed at conditions where surface melting will not occur while shock hardening, hole drilling and deep penetration welding all involve a significant amount of surface vapourization.

Three literature references exist which describe the use of lasers in situations involving surface melting. "Applied Physics Letters" Vol. 21 (1972), pp23-25 describes laboratory experiments in which thin surface zones were melted on noneutectic aluminium alloys using a pulsed laser. An experiment in which metastable crystalline phases were produced by surface melting, using a pulsed laser, is described in "Journal of Material Science" Vol. 7 (1972), pp627-630. A similar experiment in which metastable phases were produced in a series of noneutectic Al-Fe alloys is described in "Material Science Engineering" Vol. 5, (1969), pp 1-18.

U.S. 4,122,240 discloses the melting of a metal surface layer by a high energy source such as a laser to produce metallurgical changes in the surface. This patent does not teach any subsequent polishing of a surface made more homogeneous by melting.

According to the invention there is provided a method of improving the microstructure homogeneity of a metallic alloy disk substrate having second phase defects on the surface thereof, characterised in that the method comprises the steps of rotating said disk substrate at a predetermined velocity, heating said rotating substrate with a laser beam to melt said substrate surface including said second phase defects, whereby said melted second phase defects are diffused into said melted surface to produce a single phase layer on said substrate surface, and polishing said single phase surface to produce an essentially defect-free surface.

The present invention is applicable for use with aluminium alloy disk substrates which contain second phase defects therein. An example is an aluminium-magnesium alloy containing second phase defects of other material. In the case of substrates for magnetic recording disks the presence of such second phase defects on the substrate surface interferes with the application of a magnetic coating to the surface. The present invention employs a high energy source to first melt the surface layer of an aluminium substrate including melting the second phase defects thereon. The melted second phase defects diffuse into the surrounding melted material and the cooling is such that the second phase defect material can not reform the substrate surface. This produces a single phase layer which makes the substrate surface more homogeneous. This is followed by a polishing process of the cooled surface to produce a highly polished, essentially defect-free surface without changing the bulk properties of the substrate.

The invention will now be described by way of example with reference to the accompanying drawing which is a graph illustrating variations in surface melt depth as a function of the linear velocity of the substrate for different levels of applied laser power.

The present invention is particularly adapted for use in the fabrication of metallic substrates which are to be used as substrates for magnetic recording disks. Such substrates, especially those intended for use with thin film magnetic recording layers thereon produced by some type of evaporative technique, require a very smooth surface. However, the nature of the aluminium alloys used for these substrates, for example alloys of aluminium and magnesium, is such that they usually contain second phase defects which render their topography inhomogeneous. Such inhomogeneities remain in the surface of present substrates, even after efforts to remove them, such as by machining, polishing, grinding, etc.

These inhomogeneities render the substrates unattractive for use in thin film magnetic recording disks because they can result in corresponding inhomogeneities or irregularities in the magnetic layer.

In accordance with the present invention, such substrates are first subjected to annealing by a high energy source such as a laser to melt the outer layer of the substrate surface. This melting melts both the regular aluminium alloy on the surface as well as any second phase defects present thereon. After melting, the second phase defects diffuse into the surrounding melted aluminium alloy, and because of the rapid cooling after melting, these second phase defects do not reform on the substrate surface. Thus, after cooling and solidification, the surface layer is a single phase layer.

In the preferred embodiment, the circular substrate is rotated while the laser scans the rotating disk to produce the desired heating. The heating is carried out in the presence of an inert gas, primarily to prevent plasma formation, which tends to reflect incident energy from the surface to be heated and to defocus the laser beam.

It has been found that there is a maximum linear velocity of movement of the substrate relative to the scanning laser beam above which undesirable effects can occur. These effects include the formation of micro-cracks and micro-voids in the resolidified surface layer, most probably induced by stresses produced by excessive heating. In the case of the aluminium/magnesium alloy known as 5086 aluminium, the maximum linear velocity appears to be about 25.4 cms (10 inches)/second. The power density of the applied laser beam energy can be in the range of 10^4 to 10^6 watts/cm^2.

The following are examples of the use of the technique of the present invention.

Example 1

A coupon of an aluminium magnesium alloy having a thickness of 0.381 cms (0.150 inches) and identified as 5086 Al-Mg was moved at a linear velocity of 2.54 cms (1 inch)/second while a 500 watt pulsed Co_2 layer scanned the coupon surface. After treating the entire coupon surface, the annealed surface was polished to remove about .0025 cms (.001 inch) of the melted/solidified layer.

Comparison of microphotographs of the coupon surface before and after the annealing and polishing treatment of this invention showed a significant improvement in the quality of surface finish. The resulting surface was essentially defect-free and showed a smooth single phase layer extending some distance into the coupon. Cross-sectional microphotographs showed a melting of approximately the upper 0.005 inches of the substrate material.

Example 2

A disk 35.56 cms (14 inches) in diameter with a thickness of 0.381 cms (0.150 inch) and composed of the 5086 aluminium alloy was rotated at a maximum velocity of 25.4 cms (10 inches)/second while being scanned radially by a continuous wave Co_2 laser having a maximum output of 4.4 kw. Following this, the annealed layer was polished. Again, microphotographs of the surface before and after treatment in accordance with the present invention showed a major improvement in the homogeneity of the surface.

The figure is a graph illustrating the surface melt depth as a function of the linear velocity of rotation of the disk substrate for different levels of applied laser power. The shaded area from a linear velocity of 25.4 cms (10 inches)/second and lower represents the operating area for carrying out the present invention, since as indicated above, higher velocities than 25.4 cms (10 inches)/second can result in undesirable micro-voids and micro-cracks in the treated layer. As would be expected, higher levels of laser power result in greater melt depth for a given linear velocity.

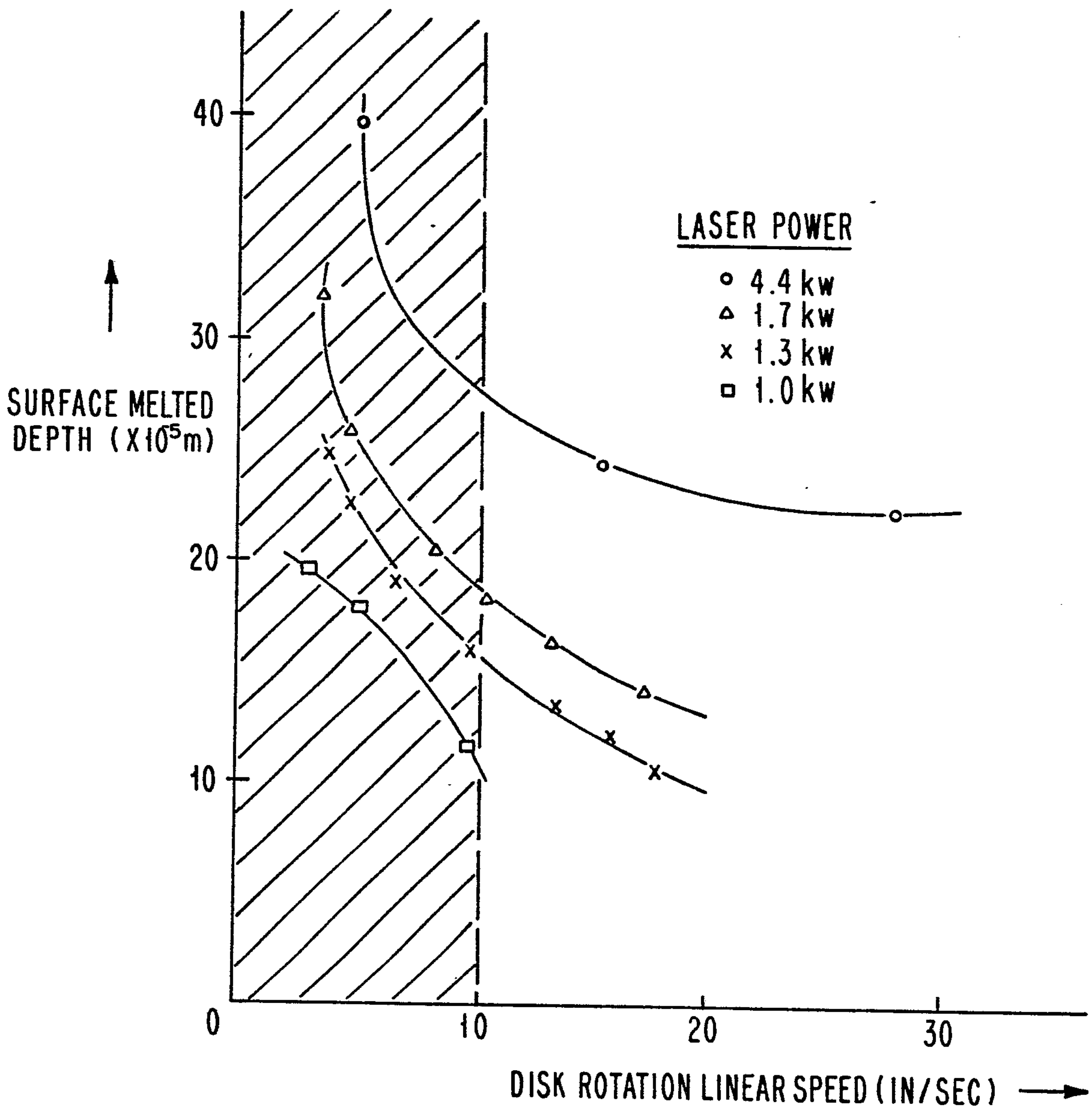
CLAIMS

1. A method of improving the microstructure homogeneity of a metallic alloy disk substrate having second phase defects on the surface thereof, characterised in that the method comprises the steps of rotating said disk substrate at a predetermined velocity, heating said rotating substrate with a laser beam to melt said substrate surface including said second phase defects, whereby said melted second phase defects are diffused into said melted surface to produce a single phase layer on said substrate surface, and polishing said single phase surface to produce an essentially defect-free surface.

2. A method in accordance with claim 1 in which said predetermined linear velocity of rotation of said disk substrate is no greater than 25.4 cms (10 inches) per second.

3. A method in accordance with claim 1 or 2, in which said disk substrate is composed of an alloy of aluminium and magnesium.

4. A method in accordance with any one of claims 1 to 3, in which said disk substrate has a thickness of approximately 0.0381 cms (0.150 inches), including the steps of melting said disk substrate surface to a thickness of approximately 0.013 cms (0.005 inches), and polishing approximately .0025cms (0.001 inches) from said melted surface.


LASER POWER
○ 4.4 kw
△ 1.7 kw
× 1.3 kw
□ 1.0 kw
SURFACE MELTED DEPTH (X10^{-5}m)
DISK ROTATION LINEAR SPEED (IN/SEC)
0
10
20
30
40