

- 1 -

APPARATUS FOR PROTECTING AND/OR REPAIRING AN OPTICAL
SURFACE

- 5 The present invention relates to apparatus for protecting,
and/or repairing damage to the surface of an optical member
and in particular to such apparatus in the form of a
composite film member.
- 10 Many optical devices include a surface, the consistency of
which is relied upon for the correct functioning of that
device. For example, with camera lenses, precision mirrors,
optical storage devices, etc., if the relevant optical
surface of such a device is damaged, e.g. scratched, then the
15 correct functioning of that device can be adversely affected.

Taking optical storage devices (OSDs) as an example, these
generally comprise a disc-like clear substrate bearing
optically recorded data and are intended to be optically
20 interrogated in order to recover the data recorded on or in
these substrates. They are exemplified (non-limitatively) by
optically recorded discs, such as compact discs (CDs).

OSDs, such as CDs, are generally durable but can be
25 susceptible to minute scratches and other surface damage
which can easily exceed in size the typical dimensions of
strings of recorded data characters. There are, of course,
quite sophisticated error recovery procedures incorporated
into the electronic systems of most units intended to
30 retrieve and/or reproduce the recorded data from such
devices, but there are limits to the capabilities of such
systems, and they can be defeated by damage which is
extensive and/or of certain types. For example, with CDs,

- 2 -

damage running arcuately along the recorded tracks is generally much more serious than similarly extensive damage running radially across the tracks. It is therefore desirable to provide a film-like member that can be applied to new OSDs
5 to protect their surfaces from damage, and/or which, if applied to the surface of an OSD that is already damaged, can at least reduce the adverse effects of such damage insofar as it affects the integrity of the data when retrieved from the OSD by optical interrogation.

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My existing UK Patent No.GB-B-2279799 describes and claims such a film-like member, in which a fluid medium is interposed between a plastics protective film and an interrogated surface of an OSD, the arrangement being such
15 that the plastics film has a refractive index close to that of the substrate of the OSD, or at least that part of the substrate through which the optically recorded data are intended to be retrieved by interrogation, for example by laser reading means. The fluid medium is of similar
20 refractive index and, as well as acting as an efficient optical coupler, flows into the surface topography of the substrate of the OSD and thus tends to fill scratches and other defects in the surface. The cohesive forces that exist within the fluid medium allow it to be spread into a thin
25 film between the plastics film and the OSD thereby tending to resist separation of the plastics film from the OSD in a direction normal to the surface of the plastics film as a result of surface tension forces. Another film may, if desired, be applied to the reverse side of the OSD and, if a
30 rim latching mechanism is used, both films can conveniently be latched in place by a common mechanism at their rims. However, as a fluid medium is used as an optical coupler between the plastics film and the OSD, such a coupler can

- 3 -

tend to travel to the periphery of the disc under centripetal/centrifugal forces during usage and ultimately be dispersed from the edges of the disc or at least to be variably effective over the surface area of the OSD. This is
5 plainly not desirable.

My International Patent application No. WO 96/21928 describes a system providing an enclosure for an OSD, having similar objectives to the aforementioned UK patent, but wherein the
10 fluid optical coupler may be replaced by a solid, malleable material that can creep into surface imperfections. The enclosure consists of suitably disposed co-operating and mating parts, and is needed because the other means for keeping the OSD and the film-like members together can be
15 insufficient; i.e. the cohesive forces within the solid malleable coupler and the electrostatic "cling-film" type forces can, for many purposes, fail to impart sufficient resistance to lateral slippage and separation between the film-like members and the OSD, promoted by the high shear
20 forces that can be generated during use of the OSD. Such high shear forces are generated, for example, with CDs, which in use are rotated at high speed relative to a reading station defined by the impingement of a laser beam on the disc. However, the use of a full enclosure to protect the OSD can
25 have disadvantages where lack of space is a problem and/or from a cost of manufacturing point of view.

An object of the present invention is seek to overcome the disadvantages of such previous arrangements.

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According to one aspect of the present invention there is provided apparatus for protecting and/or repairing damage to an optical surface, the apparatus comprising a film-like

- 4 -

member having a protective film provided with a resiliently conformable and tacky optical coupling medium adapted for adhesive retention to the said surface.

- 5 In this respect, it should be understood that it is the inherent tacky nature of the coupling medium which results in the adhesive retention thereof to the optical surface.

The adhesive tackiness of the coupling medium provides
10 significantly enhanced resistance to shear forces tending to cause lateral slippage of the film-like member relative to the surface of said device. Hitherto, for reasons which will be discussed hereinafter, it has been considered that the desired characteristics of the film-like member, particularly
15 with regard to the optimising of its refractive index and to the need for conformability of the optical coupling medium, have militated strongly against the use of adhesive tacky retention of the film-like member to the OSD. The present invention permits this advantageous arrangement to be
20 achieved.

In this respect, the tackiness of the optical coupling medium is preferably sufficient to resist separation of the coupling medium and hence the film-like member from the optical
25 surface under normal operating conditions thereof, whilst allowing manual removal of the film-like member from the surface should this be necessary or desired. On removal of the film-like member from an optical surface, the optical coupling medium
30 preferably comes away cleanly without leaving a residue so that a new film-like member can be applied without cleaning of the optical surface.

- 5 -

The tackiness of the coupling medium is further preferably sufficient to overcome the internal resilience forces of the coupling medium which will attempt to pull the coupling medium out of any surface imperfections of the optical
5 surface.

The optical surface may be provided as part of an optical storage device (OSD). In such a case, the optical coupling medium preferably thus has sufficient tackiness to avoid
10 lateral slippage of the film-like member from the OSD during normal usage of the OSD, whilst allowing manual removal of the film-like member.

Usually, though not necessarily, said surface will be one
15 through which, or from which, information borne by the device is to be derived by optical interrogation. The film-like member is thus preferably formed of an optical grade material, for example polycarbonate. However any suitable alternative material may be used, including optical grade
20 cellulose film.

According to a further aspect of the present invention there is provided a method of protecting and/or repairing surface damage to a surface of an optical member, the method
25 comprising the steps of:

- (a) providing a protective film;
- (b) providing the protective film with an optical coupling medium to form a film-like member, said optical coupling medium comprising a resiliently conformable and tacky
30 material; and
- (c) adhesively securing the film-like member to said surface by means of said optical coupling medium.

- 6 -

The optical coupling medium and the protective film may be separate elements with the optical coupling medium being applied to the film by way of a reverse gravure coating process to form the film-like member. Alternatively, the optical coupling medium may be formed integrally with the film by curing the faces of material making up the film-like member to different extents so as to provide a tacky face and a non-tacky face.

10 The invention also encompasses apparatus according to the above statements provided in the form of a sheet, and an OSD produced by means of the method described above, and/or incorporating apparatus as described above in the first statement of the invention. The invention further encompasses
15 an optical coupling medium for use in such apparatus or such a method.

In order that the invention may be clearly understood and readily carried into effect, certain embodiments thereof will
20 be described hereinafter, by way of example only, with reference to the accompanying drawings, of which:

Figure 1 shows, in plan view, a film-like member in accordance with one example of the invention, with readily-
25 releasable protective components attached thereto; and

Figure 2 shows a cross-sectional view (not to scale) of the film-like member, with protective components, shown in Figure 1.

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Before making detailed reference to the drawings, some general description of the invention will be provided.

- 7 -

Henceforth, for simplicity and to avoid undue repetition, reference will be made to the invention as applied to CDs. As has been previously stated, however, the invention is applicable to any member having a surface, the optical characteristics of which have an important function, for example, data scanners, lenses, mirrors, copiers etc. Those skilled in the art will readily appreciate the detailed modifications necessary to produce film-like members suitable for such alternative applications.

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For application to CDs, then, the invention provides a flat, annular film-like member (comprising a protective film of optical characteristics similar to those of the CD itself and a resiliently conformable tacky optical coupling medium) designed to protect at least that surface of an OSD which is intended to be interrogated, or "read", by means of a laser beam. It also provides, beneficially, the secondary function of repairing minor damage to the aforesaid surface, permitted by extension of the resilient conformable tacky optical coupling medium into scratches and the like.

The provision of an optical coupling medium is advantageous in that laser light drops in intensity by at least 5% upon passing through any surface, the 'lost' light intensity resulting from light being dispersed horizontally along that surface. Where a protective element is provided to a CD or other optical surface with no optical coupling medium, the light intensity will be reduced by at least 15% on its path each way through the protective element and the optical surface (there being three effective surfaces through which the light passes). Hence when reading a CD, the intensity of the laser light will be reduced by at least 30% in its path between the laser the pickup device of the CD player. This

- 8 -

does not take into account other light intensity attenuating effects. Moreover, in CD technology the light intensity is reduced further by absorption as it passes through the substrate of the disc. Indeed, a further percentage is lost
5 by the light passing straight through the CD silver oxide coating, such coatings being made progressively thinner to reduce manufacturing costs. The term "reflectivity" is used in the art as a measure of the reduction in the percentage of light intensity on striking a CD. By way of example, the
10 maximum reflectivity of a CD without a protective cover is around 90% (5% reduction in light intensity on entering the CD and 5% reduction on leaving the CD).

The minimum acceptable reflectivity for correct CD operation
15 is considered to be around 70% so that it will be appreciated that without a optical coupling medium between the surfaces of the protective film-like member and the CD to reduce the dispersion of light along these surfaces, problems in light pick up are likely.

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The optical coupling medium of the film-like member is secured, by way of its tackiness, both to the protective film and to the protected surface of the CD, with sufficient strength to resist the forces, active during handling and
25 playing of the CD, which tend to pull the film-like member from the CD. In particular, not only peeling forces, acting in a direction substantially perpendicular to the protected surface, but also shear forces, acting in the plane of the protected surface, are resisted without the need for further
30 clamping or enclosing devices.

The tackiness of the optical coupling medium does however allow the film-like member to be removable in that it can be

- 9 -

stripped from the CD by hand if it should require replacing. Preferably, the film-like member can be manually stripped from the CD without damage to the CD and without leaving any residue of the optical coupling medium on the CD, so that a
5 fresh film-like member may be applied to the CD without cleaning thereof.

The refractive index of the optical coupling medium may be matched reasonably closely (at least within 20%; preferably
10 within 10% and ideally within 5%) with that of the clear substrate of the CD through which the interrogating laser beam passes when retrieving the data stored on the disc. Typically, CDs have substrates of polycarbonate, having a refractive index of around 1.5, and a suitable candidate for
15 the optical coupling medium in these circumstances is a silicone based compound. Also for CD applications, the optical coupling medium should have a birefringence of less than 100nm.

20 Significant obstacles, however, militate against the use of such compounds for these purposes. Recalling that the optical coupling medium is preferably able to fill scratches and the like so as to conform to the surface and repair minor damage thereto and to provide the important adhesive retention of
25 the protective film to the protected surface, it is of immediate concern that previously known silicone compounds do not generally exhibit adhesive qualities; indeed on the contrary they are commonly used as mould release agents and perform other anti-stick functions.

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The inventor has, however, devised procedures by means of which silicone-based compounds can indeed be used with the objectives of the invention as follows.

- 10 -

Firstly, catalysts are used in a manner to prevent total curing of the silicone compound. In a partially cured condition, the compounds exhibit resilience and adhesion to the substrate and film materials proposed for use herein.

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In one example, silicone based product DC781 (Dow Corning), which is a clear acetoxysilane containing elastomers, and which cures at room temperature in about one hour, is blended with 20% silicone fluid of a higher viscosity level. This
10 prevents the DC781 product from curing completely, and it thus remains adhesive and resilient. In order to accelerate the partial curing to the order of a few seconds, however, which is advantageous for commercial production, one may dilute the silicone product with large quantities of solvent,
15 and this is not a preferred procedure, principally for environmental reasons.

In the more preferred embodiments, e.g for use with an optical storage device in the form of a CD, the optical
20 coupling medium comprises:-

a) A bulk proportion (largest constituent by weight) of:-

1) Silicon dielectric gel (refractive index 1.4074), a low viscosity silicone encapsulate that is transparent. Such gel is designed to form a cushioning, self healing, resilient
25 mass; or

2) glycidoxy and trimethoxysilyl organic group based silicone elastomers (glycidoxypropyltrimethoxysilane - refractive index 1.428). This is a fast curing silicone elastomer base which sets into a conformable coating; or

30 3) a blend of silicone polymers in hydrocarbon solvents (refractive index around 1.5);

and

b) a small proportion of Silicone fluids which are clear

- 11 -

colourless liquids, almost odourless and preferably having a viscosity of between 0 to 20,000 η . The refractive index of such fluids is around 1.5, depending on viscosity. The use of Silicone fluid in a small proportions increases the overall adhesiveness of the optical coupling medium. Reduction of catalyst elements (see below) will result in an increase in the contact adhesive quality.

More specific formulations include the blending of Silcolease 426 (Rhone Poulenc Chemicals) at 15 parts by weight ("pbw"), two fast-acting catalysts, namely Catalyst 62a and Catalyst 62B (Rhone Poulenc Chemicals) at 0.75 pbw each, Toluene (a commonly available commercial solvent) at 40 pbw and F111-10,000, a silicone oil with a high viscosity rating, available from Ambersil Limited, at 5 pbw. This blend produces an optical coupling medium with around the correct refractive index (1.55) for use with polycarbonate-based OSDs, and which exhibits the other important characteristics discussed above.

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Alternative specific formulations are:

(A) Sylgard 527 A and B silicone dielectric gel (Dow Corning) at 40 pbw, silicone oil (Dow Corning) at 10 pbw and toluene at 20 pbw. This formulation exhibits a refractive index of around 1.4.

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(B) DC781 at 40 pbw, silicone oil at 10 pbw and toluene at 30 pbw.

Both DC 781 and Sylgard 527 are silicone elastomer based, and the use of an elastomer in the optical coupling medium allows the coupling medium to conform well to the surface topography

- 12 -

of the OSD to be repaired/protected. It will be noted that the coupling medium is resilient/elastic so that it can stretch into the scratches rather than flow or creep into them. The tackiness of the coupling medium should therefore preferably be of sufficient strength to resist the natural tendency of the coupling medium material to pull out of the scratches.

A further formulation may comprise a Rhone Poulenc product called Poly200. This is a UV curable epoxysilicone. A UV cure has certain advantages in that it requires no heat for curing thus avoiding possible damage to the protective film, in particular increasing the brittleness thereof. Further, UV curing may be a cheaper and faster production process and one which does not include solvents thus being environmentally friendly. The normal formulation for this product is 100 parts polymer to 2.5 parts catalyst. The optical coupling medium is formed by reducing the catalyst by around 10% and adding 1 part silicone fluid.

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Although the use of silicone based materials for the optical coupling medium is advocated above, the invention is not entirely predicated upon such use, and (for example) contact adhesives can be used instead provided that their refractive indexes are suitable and consistent over the surface area in question.

In a further embodiment the film-like member may be formed integrally with the optical coupling medium. In this respect, the apparatus can take the form of an optical film with the correct refractive index for the surface to which it to be attached and with birefringence levels of less than 100nm. The film may be manufactured by using a liquid compound with

- 13 -

the stated characteristics and which is partially cured on one face and fully cured on the other. This will result in a film with a tacky optical coupling medium surface on one face, the other face being cured to be non-tacky and provide
5 the necessary protective element. UV sensitive catalysts may be used for this purpose where exposure of one face of the film to UV light will cause that face to cure fully while the other face will remain semi-cured and tacky.

10 Specific reference will now be made to the drawings.

Conveniently a protective film, typically (for CD protection) a polycarbonate film 1 of thickness 125 microns, is provided with an optical coupling medium 2 by means of reverse gravure
15 rollers laying down a 6 micron thickness of the optical coupling medium at 6 grams per square metre. The dimensions, of course, can be varied to suit the application for which the resulting film-like member is intended. In particular, the weight of coupling medium can differ from that quoted
20 above, and it is to be noted that in general the greater its weight, the more conformable the optical coupling medium is to the protected surface. It is preferred that the process of applying the coupling medium be carried out in a clean room to reduce the risk of impurities or other unwanted inclusions
25 being present in the optical coupling medium, which must be as smooth as possible, once cured.

It is convenient to incorporate the film-like member into a "sandwich" construction between cheap protective films with
30 release agents for transit and storage. To this end, in an overall production process, the arrangement is as follows:

A 100 micron thick film 3 of polyester, or similar

- 14 -

inexpensive material is coated with a thin (e.g. 2 micron) and very low adhesion level contact adhesive. This material is then laminated by the adhesive to the clear polycarbonate film 1 (glossy on both sides) which constitutes the protective film element of the film-like member 1,2 and is thus of thickness 125 microns as mentioned earlier. The polycarbonate film is initially provided with protective masking on one or both of its glossy surfaces; the masking on one side, if provided, being removed to permit application of the polyester film 3, which thus constitutes a carrier web.

The masking (if provided) on the other glossy surface of the polycarbonate film 1 is then removed, and the optical coupling medium 2 coated thereon to a thickness of 6 microns, preferably in a clean room as described above, thus forming the tacky and conformable optical coupling medium of the film-like member 1,2. A protective release liner 4 of about 36 microns in thickness is then applied to the medium to retain its cleanliness and integrity. It will be appreciated that the release liner can be of any convenient material that does not react with silicone and can be made sufficiently smooth that the optical coupling medium does not begin to conform to it. Typically, however, the release liner is polyester.

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The "sandwich" so constructed is then annularly cut to produce a medium suitably shaped and dimensioned for application to a CD. To this end, the release liner 4, the optical coupling medium 2 and the polycarbonate film 1 are cut by a blade from above to produce an inner diameter of 42mm and an outer diameter of 120mm. A peel tab 5 is formed at the outer edge of the release liner 4 to permit easy removal thereof by the end user.

- 15 -

The polyester carrier web 3 is cut from beneath to an inner diameter of 15mm and the same outer diameter, 120mm +/-, as the other components. These cuts are made about precisely the same centre as are the annular cuts made through the components 1,2 and 4. Moreover, the outer edge of the carrier web 3 is formed with a pair of peel tabs 6,7, diametrically opposite one another, to assist removal by the end user.

The end user applies the film-like member to a CD in the following manner:

The OSD should be cleaned and then placed, recorded (blank and shiny) side up into a normal CD storage case (often referred to as a "jewel" case). The release film 4 is then removed from the optical coupling medium 2 of the film-like member 1,2, avoiding contact with the optical coupling medium's surface by making use of the peel tab 5 on the release film 4 and the two peel tabs 6,7 on the polyester carrier web 3. The film-like member 1,2 is then placed, optical coupling medium side down, onto the CD, using the central hub in the jewel case to centralise the film-like member by its co-operation with the 15mm, centrally located cut-out hole in the carrier web 3. Once the member is properly in place on the CD, the polyester carrier web 3 is removed, again making use of the peel tabs 6,7 formed thereon, and the film-like member 1,2 is then checked for proper seating. Any visible air bubbles between the member and the CD are squeezed out by applying light, radially outward pressure with the thumbs. The top surface of the protective component 1 of the film-like member can be cleaned if necessary, and the CD is then ready for playing.

It will be understood that the embodiments illustrated show applications of the invention in certain forms for the

- 16 -

purposes of illustration. In practice, the invention may be applied to many different configurations, the detailed embodiments being straight forward for those skilled in the art to implement. For example, the dimensions of the various
5 components are variable depending on requirements. Also, whilst the film-like member is preferably formed of a plastics material, such as polycarbonate, any suitable alternative materials may be used.



- 17 -

CLAIMS

1. Apparatus for protecting and/or repairing damage to an
5 optical surface, the apparatus comprising a film-like member
having a protective film provided with a resiliently
conformable and tacky optical coupling medium adapted for
adhesive retention to said surface.
- 10 2. Apparatus according to Claim 1 wherein the protective
film is a plastics material.
3. Apparatus according to either of Claims 1 or 2, wherein
said optical coupling medium is silicone based.
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4. Apparatus according to Claim 3, wherein said optical
coupling medium includes catalysts in quantities which allow
partial curing of the silicone.
- 20 5. Apparatus according to any preceding claim including
protective, readily releasable films on at least one of said
protective film and said optical coupling medium.
6. Apparatus according to any preceding claim wherein said
25 surface is one through, or from which information is to be
derived by optical interrogation.
7. Apparatus according to any preceding claim provided in
the form of a sheet.
- 30
- 8 Apparatus according to any preceding claim wherein the
optical coupling medium is a discrete layer adapted for
adhesive retention to the protective film.



- 18 -

9. Apparatus according to any preceding claim, wherein the refractive indexes of the protective film and/or the optical coupling medium are similar to that of the optical surface.
- 5 10. Apparatus according to any preceding claim, wherein the optical coupling medium comprises elastomers to allow resilient conformability to the optical surface.
11. Apparatus according to any preceding claim, wherein the
10 optical surface is an optical storage device (OSD), and wherein the tackiness of the optical coupling medium is such as to:-
- 1) resist separation of the film-like member from the OSD under normal operating conditions;
 - 15 2) allow manual removal of the film-like member from the OSD; and
 - 3) be sufficient to overcome the internal resilience forces of the optical coupling medium which will attempt to pull the optical coupling medium out of any surface
20 imperfections in the optical surface.
12. A method of protecting and/or repairing damage to an optical surface, the method comprising the steps of:
- (a) providing a protective film;
 - 25 (b) providing the protective film with an optical coupling medium to form a film-like member, said coupling medium comprising a resiliently conformable and tacky material; and
 - (c) adhesively securing the film-like member to said surface
30 by means of said optical coupling medium.
13. A method according to Claim 12, wherein said optical coupling medium is applied to said film by a reverse gravure



coating process.

14. A method according to Claim 12 or 13, wherein the optical coupling medium is silicone-based.

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15. A method according to any one of Claim 14; wherein the optical coupling medium is formed by blending said silicone-based material with catalysts in quantities to allow partial curing thereof and thereby permit the optical coupling medium
10 to adhere to at least the optical surface.

16. A method according to any one of Claims 12 to 15 wherein readily releasable films are applied to the film and/or to the optical coupling medium for their protection
15 during storage and transit.

17. An optical storage device bearing a film-like member of apparatus in accordance with any of claims 1 to 11 and/or produced by a method according to any of claims 12 to 16.

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18. A resiliently conformable and tacky optical coupling medium for use in the apparatus of any one of claims 1 to 11 or the method of claims 12 to 17.

25 19. Apparatus for protecting and/or repairing damage to an optical surface substantially as hereinbefore described with reference to the accompanying drawings.

20. A method of protecting and/or repairing damage to an
30 optical surface substantially as hereinbefore described with reference to the accompanying drawings.