Title: **"Method of producing a protective layer on an optical component and optical component with such a protective layer".**

Corporate entity: **Diehl BGT Defence GmbH & Co. KG**

Introduction

The present proposed technical solution relates to a method for producing a protective layer on a surface of an optical component in order to protect it from degradation or damage due to environmental influences.

Problem

It is known to provide optical components, hereinafter also referred to as optical components, with optical coating layers. Such optical coatings are mainly used to suppress the reflection of optical surfaces of optical components and to increase the transmission.

Due to environmental influences of both a medial - e.g. salt water environment, humidity - and physical - e.g. stone chipping, erosion by sand or dust particles - nature, massive damage can occur to the surfaces of optical components or, if these are formed by a coating layer, to the surface of the latter. In the worst case, the coating layers can destabilise to the point of complete dissolution as a result of electrochemical corrosion and/or abrasion of the coating materials of the optical coating layer. This impairs the function of an optical component or, under certain circumstances, destroys it completely.

Previous approaches to a solution

It is known from the prior art to protect an optical component itself and/or its coating layer by covering it, for example, so that no damage occurs to the surface. DE 198 47 218 A1 proposes to protect a window, also called a dome, of a missile by providing a sliding cover with an opening in front of it. This opening then follows an optical axis of a swivelling search head optic located behind the dome, so that only that part of the dome is exposed to environmental influences which is required for the detection of a field of view by the search head optic field of view by the search head optics. Although this may increase the average service life of the dome itself, damage to the dome and thus impaired functioning of the dome and thus of the missile cannot be reliably ruled out despite the costly, elaborately controllable cover. In DE 199 53 701 A1, a type of indirect cover in the form of a dome provided with a spike with an attachment for a missile is proposed. This spike can reduce the effect of the airflow on the dome and thus, for example, erosion by sand or dust particles, but at the same time the spike impairs the detectability of an object scene by search head optics, since a "blind" spot exists at least at the attachment point of the spike to the dome.

Furthermore, it is known to provide optical components with at least a certain resistance to aqueous media by applying a hydrophobic layer to their surface, which may be formed by an outer coating layer, e.g. when the optical component or its coating layer is regularly exposed to dew during storage or use. The hydrophobic layers may be layers of monomeric coatings of fluoroalkanes or silanes. The disadvantage of these layers is that they lose their positive properties over time after only one use or in use, which means that the optical components lose their protection on the surface and can become unusable.

Solution / Implementation

The task of the proposed solution is to specify a protective layer and a method for producing such a protective layer, with which the surface of an optical component - with or without an outer coating layer - is protected from environmentally induced impairments without significantly impairing the optical properties of the optical component.

The proposed technical solution is to provide a surface of an optical component with a protective layer of a polymeric, organic material, which in particular has a high chemical resistance.

The proposed technical solution is based on the knowledge that many optical components are provided with an outer coating layer of DLC ("diamond-like carbon"), which is characterised by extreme hardness and optical transparency. If an organic, polymeric material is now applied to a DLC layer, polymerisation takes place, whereby microscopic surface defects, pores and any cracks in the coating layer can be sealed and the sensitive surface of the coating layer is electrochemically shielded from the environment and thus protected.

The organic, polymeric material is cleverly a plasma-processable coating material. By means of a plasma-based coating process, it is possible to apply protective layers of defined thickness. In particular, it is possible to apply very thin layers, i.e. layers smaller than 5 μm, preferably smaller than 3 μm, especially preferably smaller than 1.5 μm. With such thin layers, impairment of the optical properties of the optical component by the protective layer can be virtually ruled out or is very low.

Practically, the polymeric, organic material is applied to the surface of the optical component by means of a CVD plasma process ("chemical vapour deposition"). Chemical vapour deposition is characterised - especially compared to physical coating processes - by the fact that not only particularly conformal layer thicknesses can be deposited, but also complex shaped surfaces can be coated. By means of this coating process, cracks in optical components or in their coating layers can be coated or filled, as these can be regarded as a complexly shaped surface. This coating process thus allows a geometry-independent coating to be applied. If required, not only a surface of an optical component but also, for example, its mount or parts thereof can be coated. By providing an appropriate masking, parts of an optical component or its mount that are not to be coated can be excluded from such a protective coating. Coating of bonding areas or other coating layers etc. can be avoided if desired. For masking purposes, for example, a foil can be used, which can be cut to size as required. After the coating process has been completed, the film can be easily removed by peeling it off.

After the coating of the optical component with the polymeric, organic material, a process step can follow in an advantageous variant, in which a layer removal of the protective layer takes place up to a desired layer thickness of the protective layer. In this way, it is possible to reduce the protective layer until there is no significant deterioration of the optical component or hardly any to no deterioration of the optical component compared to the uncoated state, i.e. it can be detected by corresponding measurements. As a result, in particular surface defects, pores, crack initiation centres or cracks in a coating layer or the optical component itself remain sealed by the protective layer, but without significantly affecting the optical properties of the optical component.

Preferably, this process step of layer removal for reduction to a desired layer thickness - as well as the previous process step of coating - comprises a plasma treatment of the optical component. This enables a particularly targeted and easily controllable layer removal. Depending on the requirements, it is therefore not only possible to change the layer thickness subsequently, but it is even possible to completely remove this layer in areas of intact or defect-free surfaces of the optical component or its coating layer. In this process step, too, it can be useful to mask areas of the optical component and, if necessary, its holder, if no layer removal is to take place in these areas.

Practically, a tetrafluoromethane low-pressure plasma process is used for the layer removal step. The tetrafluoromethane process gas can be used to transfer the organic material to be etched into the gas phase. By adding fresh process gas and discharging the enriched process gas, a continuous material removal or layer thickness reduction is possible, which is in the nanometre range. Thus, "residual" layer thicknesses in the range of 1.5 µm or less can be realised, which hardly affect the optical properties of the optical component.

Advantageously, parylene is used as an organic polymeric material. Parylenes are a group of inert, hydrophobic, optically transparent, polymeric coating materials. Due to these properties, parylene are particularly suitable for the production of a protective coating for optical components. Parylene can be applied as a coating in a vacuum by condensation from the gas phase as a transparent and pore-free polymer film.

A particular advantage of the proposed method is that it can also be used - if necessary, again - for optical components that are already in use and originally did not have such a protective coating or were in use with such a protective coating for a longer period of time. This allows systems or assemblies with optical components to be improved in terms of their service life or to be repaired and used again after a longer period of use. The process can therefore be used several times as required. In order to carry out a repair, it is proposed in particular that the protective layer or residues of the protective layer are removed from the used optical component, in particular by a plasma treatment as described above, before a new application of a protective layer is carried out in accordance with one or more of the process steps described above.

It has been found that the proposed process is particularly suitable for optical components that have to be transparent to IR radiation in a wide wavelength range. The resistance of the sensitive optical coating layers of such optical components can be significantly improved by the process without, however, the usually strict, specified requirements for the optical properties of the optical component being deteriorated to such an extent that the optical component could no longer fulfil its function. Depending on the optical component, it is even possible to improve its optical quality by the process compared to the condition before the process as a result of reduced scattering the process as a result of reduced scattering from surface defects and as a result of layer thickness adaptation to the wavelength.

Design example

In order to protect a dome assembly for a guided missile from negative environmental influences, the outer surface of the dome assembly, comprising a dome and a dome retaining ring, is coated with a protective layer of the organic, polymeric material Parylene C. The coating is applied by means of a CVD process. However, before the Parylene C is deposited by a CVD process, the inner surface of the dome is protected from unwanted coating by masking with a Kapton film. The outer surface of the dome, which is formed by a tempering layer in the form of a DLC layer, has micropores that can be partially open up to the underlying germanium layers of the dome itself and thus form starting centres for larger defects in the event of negative environmental influences, such as dew condensation. For example, prolonged storage or use can lead to blistering and flaking of the tempering layer, so that the sensitive dome material germanium itself is exposed to negative environmental influences. To avoid this, a protective layer of Parylene C with a thickness of 3 μm is deposited on the outer surface of the dome. This is followed by a re-etching process in a tetrafluoromethane low-pressure plasma to a layer thickness of 0.6 μm. As a result, the Parylene C protective layer forms a barrier that leads to only a slight reduction in the range of 1 - 2 % of the optical transmission of the dome compared to the uncoated dome. Through the etching step, the micropores in the DLC layer remain filled or sealed by the Parylene C layer, the remaining surface of the dome is less optically affected due to the reduced layer thickness of the Parylene C layer.