

PR 6849e

1199/FL/GB

PATENT SPECIFICATION

(11) 1 262 163

DRAWINGS ATTACHED

- (21) Application No. 28814/69 (22) Filed 6 June 1969
 (31) Convention Apparatus No. 11385 (32) Filed 25 July 1968 in
 (33) Switzerland (CH)
 (45) Complete Specification published 2 Feb. 1972
 (51) International Classification G 02 b 5/28
 (52) Index at acceptance G2J 28



(54) IMPROVEMENTS IN AND RELATING TO COLD LIGHT MIRRORS

(71) We, BALZERS PATENT - UND BETEILIGUNGS-AKTIENGESELLSCHAFT a Liechtenstein joint-stock company, of FL-9496 Balzers, Principality of Liechtenstein, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to cold light mirrors such as produced particularly by the vacuum deposition of thin layers on bases, and used for example in cinema projectors for separating the heat radiation from the visible light.

A cold light mirror is known comprising a base permeable to heat radiation and thin surface layers deposited from the vapour phase, the lowest of these layers, which is mainly reflecting, consisting of purest silicon and being covered by several di-electric layers alternately of substances having a higher and lower refractive index deposited thereon from the vapour phase. This known cold light mirror comprises for example upon the silicon layer four to six layers consisting alternately of silicon oxide and titanium oxide of tantalum oxide, a silicon oxide layer being preferably arranged nearest to the silicon layer. This known proposal is based on the fact that very pure silicon is permeable to heat rays from the limit of the visible spectrum, while reflecting a considerable proportion of the visible radiation. With a suitable layer thickness a reflection of about 62% of the visible light is attained; in order to attain a reflection coefficient of more than 90%, which would be the minimum for an economic coefficient of efficiency, it may be conceivable to increase the reflection by depositing a series of interference layers on the surface of the silicon mirror so as to reach the said value. However, even when for example four additional layers consisting alternately of the oxides of titanium and silicon were deposited from the vapour phase a reflection of only about 75%, and with six additional layers of 80% could be obtained in the middle of the reflected range of the

spectrum. Experience has shown, that for a cold light mirror produced according to the known proposal with a basic layer of silicon and additional layers substantially more additional layers are required in order to attain a neat separation free from colour tints of the range of spectrum to be allowed to pass from the range to be reflected.

According to the present invention a cold light mirror is proposed which surprisingly allows the solution of this problem with considerably less layers than in the known cold light mirrors. It has been found that it is preferable to use not only one silicon layer as the mirroring basic layer followed by a multi-layer system of alternating substances of high and low refractive index, but to use several silicon layers as the individual layers of high refractive index of a multi-layer interference system.

The present invention accordingly relates to a cold light mirror comprising a base permeable to heat rays, and deposited on said base in succession, a silicon layer and interference layers alternately of high and low refractive index, wherein each layer has an optical thickness of $\lambda/4$ of the mean wave length $\lambda = 550 \text{ m}\mu$ of the visible range of the spectrum, and wherein on the first silicon layer is deposited at least one further silicon layer separated from the preceding silicon layer by a layer of lower refractive index.

A proved embodiment of the invention is constituted by a cold light mirror comprising five layers deposited upon a base permeable to heat radiation, the first layer deposited on said base consisting of silicon, the next layer of a silicon oxide, preferably SiO_2 , and the next layer again of silicon, the thickness of each layer amounting to $\lambda/4$ of the wave length, $\lambda = 550 \mu$ of the visible range of the spectrum. In order to increase the effect an additional layer of SiO_2 and one of TiO_2 is deposited thereon, each of an optical thickness of $\lambda/4$. Thereby a reflection exceeding 90% is attained in the middle of the reflected range of the spectrum, i.e. considerably more than in the aforesaid examples according to the known standing of

the prior art with the same or even a greater number of layers. The permanence property of the multi-layer systems formed according to the present invention is outstanding. In order to test the permanency thereof, the aforesaid cold light mirror was placed into 3% brine. It was found that after 100 hours no traces of destruction were shown.

Instead of using for the layer of low refractive index SiO_2 as mentioned, any other substances known to be suitable for layers of low refractive index may be used such as magnesium fluoride. With the use of magnesium fluoride even a reflection 2 to 3% higher could be attained in a five-layer system of otherwise the same composition as in the example of the invention described hereinabove. The resistance of such a system against moisture and mechanical wear was likewise outstanding. Multi-layer systems according to the invention are also of high resistance to the effects of temperature changes.

In the accompanying drawing two embodiments of a cold light mirror according to the present invention are diagrammatically illustrated by way of example, wherein:

Fig. 1 shows a section of a concave mirror, on the inside of which in accordance with the embodiment described hereinabove five layers are deposited in the following sequence: silicon, silicon oxide, silicon, silicon oxide, titanium oxide. 1 denotes the mirror base permeable to heat radiation e.g. of glass, 2 denotes the silicon layers, 3 the silicon oxide layers, and 4 the titanium oxide layer.

Fig. 2 shows a section of a plane mirror with a similar layer system, wherein 5 denotes the silicon layers, 6 the magnesium fluoride layer and 7 a titanium oxide layer.

The layer thicknesses are not shown on

scale and in both embodiments amount each to $\lambda/4$ (optical layer thickness) of the mean wave length desired.

Patent Specification No. 1,164,352 claims in claim 1 an optical filter having a transparent substrate and including at least one layer of Germanium (Ge) or Silicon (Si) and at least one other layer of a different material being either a layer of Silicon nitride or a layer of Titanium dioxide.

WHAT WE CLAIM IS:—

1. A cold light mirror comprising a base permeable to heat radiation and, deposited on said base in succession, a silicon layer and interference layers alternately of high and low refractive index, wherein each layer has an optical thickness of $\lambda/4$ of the mean wave length $\lambda = 550\mu$ of the visible range of the spectrum, and wherein on the first silicon layer at least one further silicon layer is deposited separated from the preceding silicon layer by a layer of lower refractive index.

2. A cold light mirror according to claim 1, wherein the said layers consist in succession from the base of silicon, silicon oxide, silicon, silicon oxide and titanium oxide.

3. A cold light mirror according to claim 1, wherein the said layers consist in succession from the base of silicon, magnesium fluoride, silicon, magnesium fluoride and titanium oxide.

4. A cold light mirror according to claim 1, substantially as herein described with reference to either Fig. 1 or Fig. 2 of the accompanying drawing.

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