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D E C I S I O N
of 18 April 2002

Case Number: T 0489/99 - 3.3.5

Application Number: 93305034.6

Publication Number: 0583871

IPC: C03C 17/00

Language of the proceedings: EN

Title of invention:
Method for preparing reflecting coatings on glass and mirrors prepared thereof

Patentee:
PILKINGTON UNITED KINGDON LIMITED

Opponent:
SAINT-GOBAIN GLASS FRANCE
PPG Industries, Inc.

Headword:
Coating on-line/PILKINGTON

Relevant legal provisions:
EPC Art. 56, 113(1)
EPC R. 68(2)

Keyword:
"Inventive step (yes)"
"Substantial procedural violation (no)"

Decisions cited:
-

Catchword:
-

Case Number: T 0489/99 - 3.3.5

DECISION
of the Technical Board of Appeal 3.3.5
of 18 April 2002

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 1 March 1999 revoking European patent No. 0 583 871 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: R. K. Spangenberg
Members: M. M. Eberhard
E. Lachacinski

Summary of Facts and Submissions

I. European patent No. 583 871 based on application No. 93 305 034.6 was granted on the basis of 30 claims. Claim 1 thereof reads as follows:

"1. A method of producing mirrors (2) comprising depositing onto a ribbon of hot glass during the production process a coating comprising a reflecting layer (3) and at least two reflection enhancing layers (4,5) whereby the mirrors have a visible light reflection of at least 70%."

II. Opponents 1 and 2 filed a notice of opposition requesting revocation of the patent on the grounds of lack of novelty and inventive step. The opponents relied inter alia on the following documents:

D1: US-A-4 955 705

D2: DE-A-1 913 901

D2': GB-A-1 262 163

D3: EP-A-0 456 488

D4: EP-A-0 482 933

D5: WO-A-87/01970

D6: US-A-4 100 330

D7: FR-A-2 274 572

D8: FR-A-2 391 173

D9: GB-A-1 573 154

D11: EP-A-0 305 102

D12: GB-A-2 248 853

D13: EP-A-0 172 103

D14: FR-A-2 083 818

D15: FR-A-2 011 563

D18: LOF Company sheet MIRROPANE E.P.

D19: LOF Company sheet ECLIPSE

D20: US-A-4 661 381

D21: US-A-4 847 157

D22: US-A-5 089 039

T3: Refractive indices from opponent 2

The opposition division decided to revoke the patent on the ground that the process of granted claim 1 did not involve an inventive step. It held that the technical problem was to provide an economical on-line process for making mirrors having a reflectance of at least 70% and that the claimed solution lacked an inventive step in view of the teachings of D3 (or D2) and D13.

III. The appellant lodged an appeal against this decision. He filed an amended set of claims as the first auxiliary request on 30 June 1999 and three additional auxiliary requests on 7 March 2002. Oral proceedings were held on 18 April 2002. Respondent 1 (opponent 1) did not attend the oral proceedings as indicated in his letter dated 11 March 2002. During the oral proceedings the appellant filed an amended set of claims as the main request. This set of claims differs from the granted set of claims only in that claims 13 to 30 were deleted.

IV. The appellant requested that the decision under appeal be set aside and that the patent be maintained with claims 1 to 12 filed during the oral proceedings as main request, or, as first auxiliary request, claims 1 to 11 filed with the letter dated 30 June 1999 (claims 12 to 29 deleted during the oral proceedings), or, as second auxiliary request, claims 1 to 22 of the second auxiliary request filed with the letter dated 7 March 2002, or, as third auxiliary request, claims 1 to 9 of the fourth auxiliary request submitted with the said letter. The appellant further requested reimbursement of the appeal fee. The respondents requested that the appeal be dismissed.

V. The appellant presented inter alia the following arguments:

A substantial procedural violation had taken place as the decision contravened Article 113(1) and Rule 68(2) EPC. The decision was not reasoned to the extent that the appellant was able to determine precisely what prior art documents had been relied upon and how the disclosures of the documents had been combined in a problem/solution approach to reject claim 1 for lack of inventive step. Annex 1 of the minutes of the oral proceedings referred to an apparent combination of the teaching of D2 and D3 with prior art such as D13. However, it was clear from the minutes that neither the opponents nor the opposition division had referred to said combinations of documents or made reliance on D13. The only references to D13 in the oral proceedings were by the appellant. The decision was then based on grounds upon which the patentee had not had an opportunity to present his comments.

D2' was not the closest prior art. It did not concern an on-line production during the float process and the specific product of D2', namely a cold light mirror having a visible reflectance of over 90%, could not be made on the float line since it was not possible to obtain the required high purity on-line. Starting from D2' (or D3) as the closest prior art for the sake of argument, then the technical problem would have been to provide an alternative method for producing the mirror of D2' (or D3). D2' or D3 disclosed specific multi-layer products having specific properties but not the general disclosure of a stack of layers having a visible light reflectance of at least 70%. The skilled person knew from D2' that he needed to accurately control the three parameters i) layer optical thickness, ii) layer refractive index and iii) layer composition in order to obtain the specific multi-layer mirror of D2', and that purest silicon was necessary. Deposition of the silicon was accordingly performed by vacuum deposition. Even if the skilled person had looked at D20, D21 or D6, he would have found no hint that any useful product in accordance with D2' could be produced by the on-line process. These documents were silent about the crucial parameters he needed to accurately control and in both D20 and D21 the visible light reflectance was low. D20, D21 or D6 did not suggest that refractive index and optical thickness could be controlled in a deposition on-line. The skilled person knew that he could not produce the product of D2' using the on-line process disclosed in these documents because of the presence of too many impurities in the silicon layer. The silicon layer obtained on a float production line contained impurities such as oxygen and carbon and tin vapour from the molten bath was present in the atmosphere as a further source of contamination. It could be derived for example from D23 (GB-A-1 507 996 cited by respondent 2 at the appeal stage) that the purity of the silicon layer depended on the deposition conditions. The smaller the concentration of monosilane in the gas mixture, the lower the deposition rate and the higher the impurities content. Furthermore the silicon oxide layer in the coating of D20 was not a layer contributing to the optical properties due to its very low thickness. This layer was grown in situ and its thickness could not be controlled. D20 did not teach that a layer of the required thickness could be formed in the annealing lehr. In D21 the interlayer was made of TiN, ie a material which absorbed in the visible region of the spectrum.

The skilled person would not have been motivated to combine the teaching of D2′ with the teaching of D13. There was no suggestion that if the aluminium layer of D13 were applied downstream of a float tank at a temperature ≤ 500°C, subsequent layers could be deposited there over. The disclosures of D3 and D13 were so incompatible that it was not possible to mosaic them together in an attempt to solve the objective technical problem present in the prior art. Furthermore, since the reflectance values achieved with the process of D13 were likely to be high, there was no motivation to the skilled person to incorporate into these mirrors additional layers such as those employed in D2' or D3.

VI. Respondent 1 put forward the following arguments in reply to the grounds of appeal. The process of claim 1 lacked an inventive step with respect to the disclosures of D3 and D13. The teachings of these two documents were compatible. D3 disclosed the layer structure as defined in claim 1 and further mentioned deposition techniques at an atmospheric pressure, such as thermal oxidation, which was a pyrolysis, or conventional "wet, dip and dry" method. The process of D13 did make it possible to apply successively several layers to the glass ribbon while it travelled through the lehr taking into account the length thereof and the temperature of the glass in the lehr. D13 disclosed all the features of claim 1 except the use of two dielectric layers which enhanced the reflectance of the reflecting layer. The skilled person would have been motivated to apply additional dielectric layers to the coated substrate of D13 since, starting from D13 as the closest prior art, the technical problem would have been to further improve the product quality, ie to increase its visible light reflectance. Both D2 and D3 were very relevant as they disclosed the same layer structure as in claim 1. Starting from D2 or D3, it was the routine task of the skilled person to look for a more economical and simpler process for manufacturing these mirrors and to change from the off-line deposition to an on-line deposition during the float process using the more recent technology concerning the said on-line deposition. The appellant's arguments that the skilled person would not have considered D2 because of the requirement of a very pure silicon layer could not be accepted since it was obvious to achieve a less ambitious objective by accepting less pure layers. Furthermore the skilled person could have expected a higher density of the coating by using pyrolytic deposition instead of vacuum deposition. The reflectance value of 70% in claim 1 was not a critical threshold. The cited documents concerning mirrors showed that they could be devised so as to achieve a very high reflectance such as in D2, or a lower reflectance such as in D3, D4 or D18. This value could be controlled by choosing the thickness of the material and was generally prescribed by marketing studies, depending on the envisaged use and production costs.

VII. Respondent 2's arguments can be summarised as follows:

If the closest prior art were a document concerning the on-line coating of glass during the float process and not a document concerning the production of a mirror, then D18 would be closer than D5. Starting from D2' as the closest prior art, the technical problem would not be the production of a cold light mirror but the provision of an on-line process for producing mirrors having a reflectance of at least 70%, as stated in the decision under appeal or in the patent in suit. D2/D2' taught the skilled person the optical thickness, the kind of layer, the sequence of layers with low and high refractive index. The refractive indices of SiO_2 and silicon were generally known from handbooks as shown in T3. The refractive index of a silicon layer was disclosed in D7. The glass manufacturer having as an objective the on-line production of a mirror with a high reflectance would have inferred from the general statement on page 1 of D2' that a visible light reflectance of 75% could be obtained with less layers and without using the purest silicon since the high reflectance resulted from alternating several layers of low and high refractive index. Furthermore, D2/D2' disclosed the deposition of silicon from the vapour phase. This included chemical vapour deposition. D20 disclosed the on-line production of a multi-layer coating during the float process. There was no prejudice against the deposition of a silicon layer, a silicon oxide layer or a metal oxide layer within the reducing atmosphere of the float chamber. D20 disclosed the kind of material to be used and the thickness of the layers, including that of the silicon oxide layer which could be controlled. The function of the silicon oxide layer in D20 was the same as in claim 1, ie a reflection enhancing layer. The skilled person knew the refractive indices from handbooks and was also aware of the appropriate stack of layers. If the thickness of the silicon oxide layer given in D20 were not sufficient, then it would have been obvious to increase it by increasing the time of contact with oxygen. D21 disclosed how to produce a multi-layer coating on-line during the float process. The layer thicknesses reported in D21 were similar to those used in example 3 of the patent in suit, and TiN had a refractive index similar to that of silicon oxide. D21 further disclosed the use of three coating distributors in the float chamber. The silicon layer was made of pure silicon since it was obtained by pyrolysis of monosilane. Neither D20 nor D21 mentioned that the silicon layer contained impurities. Replacing TiN by SiO_2 was obvious to the skilled person knowing that TiN absorbed in the visible region of the spectrum.

Reasons for the Decision

1. The appeal is admissible.

2. The process as defined in claim 1 is new with respect to the cited prior art. This was not disputed by the respondents at the appeal stage. Therefore further considerations in this respect are not necessary.

3. Turning to the issue of inventive step, there was no agreement between the parties as to which document represents the closest prior art. It might be derived from respondent 1's submissions at the appeal stage that he considered either D13 or D2 as the closest prior art. In his notice of opposition respondent 1 considered seventeen combinations of two documents alternatively taking D1, D2, D3, D4, D5 or D6 as the starting prior art document. Respondent 2 considered D2'/D2 as the closest prior art at the appeal stage. In the appellant's opinion, D5 (or its equivalent D20)

represented the closest prior art as it discloses the on-line coating of glass during the float process. However, D5 does not concern the production of mirrors having a high visible light reflectance but the production of coated architectural glass with a reflectance of only 45%. As D13 discloses both the production of mirrors and the on-line deposition of aluminium onto a ribbon of hot glass during the float process, it might be considered as the closest prior art. However, taking into account that D13 does not concern the manufacture of a multi-layered mirror contrary to D2/D2', the board can follow the respondents' approach starting from D2/D2' as the closest prior art although the deposition is not performed on-line.

3.1 More precisely, D2' discloses a cold light mirror which comprises a base permeable to heat radiation such as glass, a first silicon layer deposited on the glass and interference layers alternately of high and low refractive index, 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. Each layer has an optical thickness of $\lambda/4$ of the mean wavelength λ = 550 nm of the visible range of the spectrum. The layers are deposited in particular by vacuum deposition. The layer of lower refractive index is preferably a silicon oxide layer. A cold light mirror with five layers consisting, in succession from the base, of a silicon layer, a SiO_2 layer, a silicon layer, an additional SiO_2 layer and a TiO_2 layer exhibits a visible light reflectance exceeding 90% in the middle of the reflected range of the spectrum (see D2', claims 1 and 2; page 1, lines 10 to 15 and 70 to 96).

Starting from this prior art, the technical problem underlying the patent in suit can be seen in the provision of a method for producing a mirror of high visible light reflectance in a more efficient way, the mirror being suitable for a wide range of purposes including domestic use (see patent in suit page 2, lines 55 to 57; page 6, lines 10 to 17).

It is proposed to solve this problem by the process as defined in claim 1 which differs from the process of D2' in that the multi-layer coating is deposited onto a ribbon of hot glass during the production process. In view of Examples 1 to 5 of the patent in suit, it is credible, in the absence of evidence to the contrary, that this technical problem has actually been solved by the process of claim 1. This was not disputed by the respondents.

Respondent 2 argued that the technical problem with respect to D2'/D2 would be the provision of an on-line process for producing mirrors having a high reflectance (or a reflectance of at least 70%) as derivable from the patent in suit. The board cannot accept this definition of the problem since the on-line deposition of the multi-layer coating onto the glass substrate during the production process is clearly an essential element of the claimed solution, and thus this definition includes pointers to the solution. In accordance with the established case law of the Boards of Appeal, the board holds that the technical problem addressed by an invention has to be formulated in such a way that it does not contain pointers to the solution or does not partially anticipate the solution (see Case Law of the Boards of Appeal, 3rd edition, ID-4.1, page 115).

3.2 D2'/D2 contains no information suggesting that the multi-layer coating might be obtained by applying the layers on-line to the glass during the glass production process. The disclosure of vacuum deposition as the deposition method for manufacturing the cold light mirror in D2' cannot hint towards an on-line deposition. The fact that, in the discussion of the prior art about cold light mirrors, D2' does not expressly refer to vacuum deposition but discloses deposition "from the vapour phase", ie a less precise term which might include the deposition from vaporised species other than vacuum deposition, does not suggest that a multi-layer coating comprising two silicon layers and a silica layer as disclosed in D2'/D2 could be applied on-line to glass during the production process.

Respondent 2's argument that the skilled person would have inferred from D2' that a high visible light reflectance of for example 75% could still be obtained both with less layers and without using very pure silicon is not convincing. In the analysis of the prior art concerning cold light mirrors, D2' makes reference to a known cold light mirror comprising a layer of purest silicon covered by several dielectric layers alternately of substances having higher and lower refractive index, the layers being deposited from the vapour phase. With a layer of the purest silicon and 4 to 6 layers consisting alternately of silicon oxide and titanium oxide or tantalum oxide, a visible light reflectance of only about 62% can be attained. When four additional interference layers consisting alternately of titanium oxide and silicon oxide are further deposited from the vapour phase a reflectance of about 75%, and with 6 additional layers of 80%, could be obtained. The invention disclosed in D2' allows attainment of the desired high reflectance with considerably less layers than in the known cold light mirrors by using not only one silicon layer but several silicon layers as the individual layers of high refractive index of a multi-layer interference system, each layer having an optical thickness of about $\lambda/4$ (see page 1, lines 16 to 49, and 58 to 81). A visible light reflectance over 90% is attained with a five-layer system deposited by vacuum deposition and consisting of $Si/SiO_2/Si/SiO_2/TiO_2$ (see page 1, lines 10 to 13 and 82-96). The five-layer system exemplified in D2' and having a visible light reflectance of over 90% as well as the known mirror exhibiting a reflectance of 75% with ten interference layers over the silicon layer both comprise very pure silicon and there is no suggestion in D2' that a visible light reflectance of at least 70% could still be obtained by further reducing **both** the number of layers to less than five and the purity of the silicon layer.

4. Each of D20 and D5 discloses a process for producing a coated architectural glass on-line wherein the coating is applied to a ribbon of hot glass on the float glass production line. A silicon coating is applied to the ribbon of hot glass by chemical vapour deposition (hereinafter CVD) as it travels through the float glass tank, the silicon coating is then oxidised to a sufficient extent before a metal oxide coating is applied to the coated glass in the annealing lehr. The exemplified architectural glass, which carries a multi-layer coating comprising a reflective silicon coating, 30 nm thick, a silicon oxide film, 2 to 5 nm thick, and a tin oxide film 20 nm thick, has a daylight reflectance of 45%. The tin oxide coating may be replaced by a titanium oxide, silica or alumina coating

(see D5, page 1, lines 8 to 18; page 4, lines 2 to 8; page 5, line 20 to page 6, line 33; page 9, lines 30 to 33; and D20, column 1, lines 7 to 17; column 2, lines 36 to 42; column 3, line 25 to column 4, line 5; column 5, lines 44 to 47).

Although D20/D5 teaches the on-line deposition during the float process of a silicon coating and a metal oxide coating, and the growth of an intermediate silicon oxide coating, it also shows that the resulting coated glass has a visible light reflectance which would not be sufficient in particular for mirrors for domestic use. The respondents' arguments that the silicon oxide layer grown on the silicon layer is a reflection enhancing layer like the intermediate silicon oxide layer in the mirrors of D2' and that the skilled person would have applied the teaching of D20/D5 to the production of mirrors of the kind disclosed in D2', are not convincing for the following reasons. According to D5/D20 the function of the silicon oxide layer is to avoid the formation of defects called "pinholes", which occurs when successive silicon and tin oxide coatings are formed on the glass. The extent of oxidation of the silicon layer and, thus, the thickness of this layer depends upon the temperature at which the treatment with tin tetrachloride is carried out. With the glass at a temperature of 521°C, the silicon oxide film is 2 to 5 nm thick, whereas with a glass temperature of 632°C a thickness of 6 to 9 nm is necessary to avoid pinholing (see D5 page 3, lines 27 to 30; page 11, lines 6 to 27; claim 1; and D20, column 2, lines 26 to 29; column 6, lines 23 to 46; claim 1). Thus the function disclosed in D5/D20 is completely different from the one alleged by respondent 2. Furthermore, respondent 2's allegation was not substantiated and was contested by the appellant who drew the attention to the extremely low thickness of the layer. The composition, refractive index and absorption coefficient of the silicon oxide layer are not stated in D5/D20 and, therefore, it is not clear to the board on which data respondent 2 based his allegation. Although the burden of proof rests on respondent 2, he has provided no evidence that this very thin layer actually acts as a reflection enhancing layer. In these circumstances, the board is not convinced that the skilled person would have derived from D5/D20 that this silicon oxide layer is a reflection enhancing layer of the kind disclosed in D2'/D2. D20/D5 also does not disclose the refractive index and absorption coefficient of the other layers. Therefore, it cannot be inferred from D20/D5 whether or not the on-line deposition process disclosed therein would allow the deposition of at least three layers having the appropriate characteristics leading to the desired high visible light reflectance. In this context respondent 2 argued that the refractive index of materials such as silicon and silicon oxide was well-known as shown in T3 or could be found in handbooks. However, it is also well-known that the refractive index of silicon and silicon oxide layers depends on their method of preparation. This was undisputed. T3 (an internal document from respondent 2) indeed gives the refractive index of silicon and SiO_2 at different wavelengths, but it is not stated how the silicon layers were prepared. Respondent 2 provided no information as to where the data of T3 came from, whether or not they concerned amorphous silicon or how this silicon was prepared although this matter had already been discussed in the opposition proceedings. Evidence that the refractive index of a silicon layer prepared as disclosed in D20/D5 was indicated in a handbook was not provided. Furthermore, the silicon layer was deposited in D20/D5 from a mixture composed of 86% nitrogen, 10% monosilane and 4% ethylene (volume%) and it is disclosed that the ethylene changes the nature of the silicon coating on the treated glass since its resistance to alkali is improved by comparison with a silicon coating produced with only nitrogen and monosilane (see D5 page 10, lines 9 to 11; page 14, lines 1 to 14; D20, column 5, lines 58 to 61; column 7, line 57 to column 8, line 2). In view of this teaching the skilled person could not have expected the silicon coating deposited in D20/D5 to be of a sufficient purity to achieve the required high visible light reflectance, all the more so since, independently of the presence of ethylene, the conditions in the float glass process are not comparable to those of a vacuum deposition. The atmosphere in the float tank is contaminated with tin vapour from the molten tin bath, oxygen may diffuse from the glass at the glass temperatures used in the on-line deposition during the float process and carbon contamination from the coating heads may occur as indicated by the inventor at the oral proceedings. It can be inferred from D7 or D23 that the refractive index of a silicon layer applied by CVD on a float production line from a gaseous mixture containing nitrogen, monosilane, optionally hydrogen and no ethylene may vary from for example 2.9 to 4 depending on the operating conditions, in particular on the composition of the gaseous mixture containing the monosilane. In D9 where the reflective silicon-containing coating was deposited on-line during the float process in the presence of ethylene, the refractive indices of the silicon-containing coating vary from 2.45 to 3.5. Respondent 2's arguments that it would have been obvious to the skilled person to increase the thickness of the silicon oxide layer in the process of D20 if it was too low to achieve the desired high reflectance are not convincing. Although it can be inferred from D20/D5 that the extent of oxidation of the silicon layer, and thus the thickness of the silicon oxide layer, can be controlled by adjusting the oxidation conditions, ie the time, oxygen partial pressure and temperature (see page 11 lines 10 to 14; D20, column 6, lines 27 to 32), an increase of the thickness of the silicon oxide layer is necessarily accompanied by a decrease of the silicon layer since the latter is consumed. Therefore, both the thickness of the silicon oxide and the thickness of the silicon layer would have to be increased to arrive at the desired high visible light reflectance. In addition, according to D2'/D2 the multi-layer coating contains two silicon layers in order to achieve a high reflectance with less interference layers. This means that, in the on-line deposition process of D20/D5, a second silicon layer should be deposited onto the silicon/silicon oxide layers instead of the metal oxide layer which is applied in the oxidising atmosphere of the lehr. However, D20/D5 does not contain information suggesting that it would have been possible to apply a further silicon layer with the appropriate optical characteristics onto the glass coated with the silicon and silicon oxide layers already having a thickness greater than those disclosed in D20/D5. Respondent 2's argument that the skilled person would have positioned three coating distributors in the float section is based either on an ex-post facto analysis or on a combination of the teachings of D2'/D2 and D20/D5 with further prior art documents since it cannot be inferred from D20/D5 that three coating heads might be used in the float section. This is also not in agreement with the teaching of D20/D5 regarding the way the intermediate silicon oxide layer is formed. The board observes that the possibility of pyrolytically forming a silicon oxide coating within a float chamber is disclosed in D22; however, it is not suggested in D22 that two additional silicon layers having the appropriate optical characteristics might be deposited in the float chamber, one before and the second after the silicon oxide layer. Respondent 1 argued that the skilled person could have feared obtaining a less pure silicon by replacing vacuum deposition by a pyrolytic process on the float production line but would have expected a higher density, thus implying that the negative effect of a less pure silicon on the reflectance might be compensated by a higher density. As respondent 1 has not provided evidence in support of this contested allegation, the latter cannot be accepted by the board. For the preceding reasons the board is not convinced that the skilled person would have contemplated using the on-line deposition during the float process known from D5/D20 to produce a multi-layer coating of the kind disclosed in D2'/D2 in order to solve the technical problem indicated above.

5. Concerning the combination of the teaching of D2'/D2 with the teaching of D21, the board observes the following. D21 discloses the manufacture of a coated heat reflective architectural glass on-line during the float glass process. Three gas distributors are disposed within the float chamber to coat the glass successively with a first silicon coating, then a titanium nitride coating over this first coating and a second silicon coating covering the titanium nitride coating, the multi-layer coating being produced by CVD (see abstract; column 1, lines 13 to 31; claim 1). However, the visible light reflectance of the coated articles from the glass side is very low, ie 32.5% or less in the examples. In Examples 1 and 2, in which the articles have the highest visible light reflectance, the thicknesses of the layers are respectively 20 to 30 nm (1st silicon layer), 90 to 110 nm (titanium nitride layer), 10 to 20 nm (2nd silicon coating). D21 neither discloses the refractive index and absorption coefficient nor the optical thickness of the layers. Therefore, it cannot be inferred therefrom that the on-line deposition would have made it possible to deposit a multi-layer coating having the degree of purity and optical characteristics necessary for obtaining a high reflectance. Respondent 2's calculations in T2a to T2h

submitted during the opposition proceedings cannot be taken into account since they are based on refractive indices which are not disclosed in D21 and respondent 2 did not provide the required information as to where they came from and which kind of material they concern. It is observed in this respect that the refractive index of 4.2975 selected for Si is higher than the values given in the cited documents involving the on-line deposition of a silicon layer from monosilane by CVD during the float glass process. The selected combination of thicknesses used in the calculation is also not disclosed in D21. Furthermore, as already indicated above in connection with D20/D5, the skilled person would not have expected the deposition of the silicon layer in the float chamber to result in a sufficiently pure silicon taking into account the contamination risks in the float chamber even in the absence of ethylene in the gaseous mixture. Moreover, the process of D21 involves the deposition of a titanium nitride layer as the intermediate layer whereas, according to D2'/D2, the layer between the two silicon layers is either a silicon oxide layer or a magnesium fluoride layer. There is no suggestion in D21 that it would have been possible to form a multi-layer coating consisting of a silicon layer, a silicon oxide layer, and a second silicon layer, each having a sufficient purity and the appropriate optical characteristics, in the float chamber using the three gas distributors 27, 28 and 29 illustrated on Figure 1 of D21. D21 also does not disclose how to perform the deposition of a silicon oxide layer in the float chamber after the deposition of the first silicon layer. For all the preceding reasons the board is not convinced that the skilled person would have contemplated applying the on-line deposition in the float chamber disclosed in D21 to the production of a multi-layer coating of the kind disclosed in D2'/D2 in order to obtain a mirror having a high visible light reflectance.

6. In a further line of argument, respondent 2 relied on a combination of the disclosure of D2'/D2 with the teaching of D6. D6 also concerns the production of architectural glass. A silicon layer is applied on-line to the hot glass ribbon in the float chamber using monosilane and nitrogen in the gaseous mixture. After the glass ribbon has advanced beyond the non-oxidizing atmosphere of the float chamber, the silicon coated glass is contacted with a coating composition containing an organometallic reactant which thermally decomposes on contact with the hot glass to form a metal oxide coating, for example tin oxide or titanium oxide (see col.2, lines 1 to 40). The silicon/metal oxide coated glass of example 3 has a luminous reflectance of 58%. D6, like D20 and D21, neither indicates the refractive index nor the absorption coefficient of the layers. Furthermore, it cannot be inferred from D6 that the second silicon layer which, according to D2'/D2, would be necessary for obtaining the desired high visible light reflectance, might be deposited on the float glass production line after the deposition of the metal oxide layer. It is also not derivable from D6 that the appropriate optical characteristics might be achieved by depositing the multi-layer coating on the float production line, where the conditions are not comparable to those of a vacuum deposition as regards the contamination risks. The considerations in the preceding paragraphs in connection with D20 and D21 partly apply to the combination of the teachings of D2' and D6.

7. D18 discloses an architectural glass which appears as a mirror from one side and as a window from the other side. The reflective coating is applied to the glass during manufacture. The visible reflectance of this article having a mirror-like appearance is 60±5%, ie less than that stated in claim 1. In the absence of more information about the structure of this transparent mirror which, according to respondent 2, comprises a silicon layer, D18 can neither be considered as the closest prior art, nor can it hint at the claimed subject-matter in combination with the cited documents. The same remarks apply likewise to the architectural glass of D19 which exhibits a visible light reflectance of 45% and whose coating is deposited onto the glass on the float glass production line.

8. D13 discloses the production of mirrors by depositing an aluminium layer or an aluminium-alloy layer onto the hot glass surface in the float glass process, when the glass ribbon has exited the float tank and is at a temperature ≤ 500°C. The coating is applied by flame spraying using a flame gun to melt the aluminium or aluminium alloy. The thickness of the coating is from 10 to 20 µm (see claims 1 and 5; page 5, lines 1 to 7 and 33 to 37). This method is thus used in D13 to apply a relatively thick aluminium film, in any case much thicker than the individual layers of D2'/D2. The structure of the mirror according to D13 differs completely from the multi-layered mirror of D2'/D2. It cannot be inferred from D13 that three layers differing completely from that of D13 and having the appropriate purity, refractive index, thickness and thickness uniformity might be applied to the glass ribbon on the float production line. There is also no teaching in D13 as to how the silicon layers and the metal oxide layer

of D2'/D2 could be deposited on-line. Therefore respondent 1's arguments that the claimed method is obvious in view of the teachings of D2/D2' and D13 are not convincing.

9. The board can also not accept respondent 1's arguments that the subject-matter of claim 1 would lack an inventive step in view of a combination of the teachings of D3 and D13. The front surface mirror of D3 comprises a substrate and a multi-layer coating formed of a reflective metal layer such as a Cr, Ni-Cr alloy, stainless steel, Al or Rh layer, and two dielectric layers. The latter consist of a low refractive index dielectric layer such as silicon oxide, followed by a high refractive index layer such as titanium oxide. These two layers increase the reflectance of the metal layer. In the embodiment of Figure 2, the visible light reflectance of the Cr layer of about 65% can be enhanced by the two dielectric layers to approximately 84%. The layers are deposited by a DC sputtering process using rotating cylindrical magnetron (see claims 1, 5, 6 and 9; page 3, lines 13 to 34; page 4, line 24). With respect to D3 the technical problem to be solved would be the one indicated in point 3.1 above.

As indicated above, flame spraying is used in D13 to apply, on-line, a relatively thick aluminium film to the hot glass ribbon. It cannot be inferred from D13 that this method would be suitable for manufacturing mirrors with a structure as defined in D3, which requires high purity and precise, uniform film thicknesses. D3 teaches that there are other techniques than DC sputtering for depositing dielectric films, for example thermal oxidation or low pressure CVD, however, they suffer from, among other things, low deposition rates. The conventional "wet, dip and dry" methods used for large scale operations are said to be inadequate for applications requiring high purity and precise, uniform film thicknesses (see page 4, lines 25 to 30). Therefore, there is a disincentive to the skilled person against using techniques other than DC sputtering for the deposition of the multi-layer coating of D3. In these circumstances, the skilled person would not have been encouraged to deposit these layers, on-line in the annealing lehr, using the said methods. D13 also does not contain any information suggesting that the deposition of two subsequent layers over the solidified aluminium layer in the annealing lehr would be technically feasible, let alone two layers having the required purity and uniform thickness. There is also no suggestion in D13 as to how the deposition techniques mentioned in D3 could be incorporated into a float line. Respondent 1's argument that it was the normal task of the skilled person to change from the off-line deposition to an on-line deposition during the float process using the more recent technology concerning the on-line deposition, is not convincing since D13 neither suggests that the production of a multi-layer coating including interference layers would be technically feasible on-line nor discloses the technology necessary for manufacturing such products on-line.

10. The line of argument of respondent 1 based on D13 as the closest prior art cannot be followed by the board for the following reasons. Starting from D13, the technical problem would not have been to further improve the visible light reflectance since, as pointed out by the appellant and not contested by the respondents, the reflectance of a mirror having a thick layer of aluminium would already be higher than 70%. Furthermore, none of the documents D2, D3, and D13 suggests that it would be technically feasible to apply two dielectric layers over the solidified aluminium layer, on-line, in the annealing lehr. In addition, the

two dielectric layers applied onto the thick aluminium layer of D13 would not have been reflection enhancing layers as required in claim 1 since the mirror of D13 can only be a back surface mirror as pointed out by the appellant. This was not disputed by the respondents.

11. Respondent 1 further considered that the claimed method lacked an inventive step in view of the teachings of D5 and D2'/D2, starting from D5 as the closest prior art. In the board's view D5/D20 is not an appropriate starting document for assessing inventive step since it does not concern the fabrication of mirrors. However, if, for the sake of argument, D5/D20 were taken as starting point, the technical problem with respect to D5/D20 would appear to be the provision of another on-line process for manufacturing coated articles, which can be used for the production of mirrors suitable for a wide range of purposes including domestic use. The board is not convinced that, in view of the teachings of D5/D20 and D2/D2', the skilled person would have arrived at the claimed solution without exercising an inventive step for the reasons indicated above in points 3.2 and 4.

12. In reply to the grounds of appeal, respondent 1 indicated that it maintained the grounds for opposition put forward in the notice of opposition. In the latter, respondent 1 further relied on the following combinations of documents to support its allegation of lack of inventive step in connection with claim 1: D1 + D11, D1 + D5, D1 + D6, D1 + D7, D1 + D8, D1 + D9, D2 + D11, D3 + D15, D3 + D12, D3 + D13, D3 + D14, D4 + D15, D4 + D12, D4 + D13, D4 + D14. Although D1 and D4 concern multi-layered mirrors, these documents are less relevant than D2/D2' or D3 and cannot be considered as the closest prior art since they neither disclose mirrors exhibiting the required visible light reflectance of at least 70% nor the on-line deposition

of a coating onto glass during the production process. Furthermore, D7, D8, D9, D11 and D15 all disclose processes for applying a coating to glass, on-line, during the float process; however, none of them discloses the on-line deposition of successively three layers during the float process. In this respect they are also less relevant than D21 considered above. Although D14 discloses the application of three layers onto the hot glass ribbon during the float process, it is also less relevant than D21 since two layers are metal layers which are applied to the glass by condensing metal vapours, for example a Pd-Ni layer, as the primer metal layer, and a gold layer, as the layer imparting the desired reflecting properties (see claims 3, 4 and 8). D12, which concerns the manufacture of mirrors and mentions the deposition of an aluminium layer on-line during the float process, is also less relevant than D13 considered above. As the deposition is performed at a temperature of 180°C, this low temperature would not permit subsequent deposition of two reflection enhancing layers on-line, for example by a CVD process. Therefore the combinations considered above are in any case less relevant to the claimed process than those envisaged above in points 3 to 10. Furthermore, in reply to the notice of opposition, the appellant submitted detailed reasons as to why the claimed process would involve an inventive step with respect to each of the 16 combinations of documents indicated above. Respondent 1 has not contested the appellant's arguments and the board considers most of these arguments to be convincing.

The remaining documents cited by respondent 1 also contain no additional information which, in combination with the teaching of the preceding documents, would point towards the claimed process.

13. It follows from the above that the subject-matter of claim 1 according to the main request meets the requirement of inventive step set out in Articles 52(1) and 56 EPC.

14. Claim 1 being allowable, the same applies to dependent claims 2 to 12, whose patentability is supported by that of claim 1.

15. According to Rule 67 EPC the reimbursement of the appeal fee shall be ordered where the board deems the appeal to be allowable if such reimbursement is equitable by reason of a substantial procedural violation. Granted claim 1 being considered to meet the requirement of the EPC, the first condition of Rule 67 is fulfilled.

According to the appellant, the appealed decision is not sufficiently reasoned to determine precisely what prior art documents have been relied upon and how the disclosures of the documents have been combined in a problem/solution approach to reject claim 1 for lack of inventive step. The board observes that a technical problem is defined in point 4.7 of the decision under appeal with respect to prior art documents which are identified in point 4.2. In the next paragraphs 4.7.1 and 4.7.2, D3 is analysed in detail and reference is made to both the teaching of D3 and D2 as prior art showing that the claimed reflectance may be achieved without using Ag or Al as the reflecting layer. The question is then raised in point 4.7.3 whether or not it would have been obvious to arrive at the claimed reflectance values by using the claimed conditions. It can be understood in this context that the said conditions are in fact the on-line deposition of the multi-layer coating onto a ribbon of hot glass during the production process. It is derivable from point 4.7.4 that D2 and D3 do not concern the on-line deposition of the coating on a float glass production line. It is further stated that D3 discloses the possibility of employing many coating methods and D2 alluded to vapour phase deposition methods. D1 is also mentioned as a document disclosing several techniques for applying metal and dielectric layers. According to point 4.7.5 of the decision, the skilled person would investigate the conventional coating methods used in combination with a float glass production and would find for example in D13 that it was technically not difficult to apply a main reflecting layer on-line on a ribbon of hot glass. Although the last sentence of paragraph 4.7.5 does not expressly refer to the documents cited in the preceding points, it is clear from point 4.9 that lack of inventive step was based on the combination of two of the cited documents. It is indeed not stated in this point which two documents were combined; however, it can be understood in view of the considerations in points 4.7 to 4.7.5 that the teaching of D13 was combined with the teaching of D3, or with the teaching of D2 to arrive at the finding of lack of inventive step. There remain doubts as to whether or not lack of inventive step was also objected to on the basis of a combination of D1 with D13. However it does not follow therefrom that the decision contains no adequate reasoning as to why the process of claim 1 lacks an inventive step since it is sufficient for the requirement of Rule 68(2) EPC to be met that a reasoning is given in connection with one particular combination of documents.

Regarding the requirement set out in Article 113(1) EPC, the appellant argued that neither the respondents nor the opposition division had made any specific reference to a combination of the teaching of D2 and D3 with the teaching of D13 in the oral proceedings, the only reference to D13 being from the appellant, so that the decision was based on grounds upon which the appellant had not had an opportunity to present comments. The board observes that according to the minutes of the oral proceedings before the opposition division, the appellant presented comments upon D13 at the oral proceedings. D2 and D3 were also discussed at the oral proceedings. However, it is indeed not derivable from the minutes that the **combination** of the teaching of D2 or D3 with the teaching of D13 was expressly discussed in connection with the inventive step issue. In the notice of opposition of respondent 1, it was however objected that the subject-matter of claim 1 lacked an inventive step with respect to a combination of the teachings of D3 and D13, starting from D3 as the closest prior art (see point 5, pages 9 to 11 of the notice of opposition). In his reply to the notices of opposition, the appellant presented comments as to why the claimed process would not be obvious in view of a combination of the prior art documents concerning mirrors having a high visible light reflectance, such as D2 and D3, with the prior art documents disclosing the deposition of metal layers directly onto the glass ribbon during float glass production, such as D12 or D13. The combination of D3 with D13 was in particular considered : see pages 8 to 9 and page 18 of the appellant's letter dated 15 April 1998. Therefore, the appellant had already had an opportunity to present comments on such a combination before the oral proceedings and had indeed put forward arguments in writing about both this combination and the combination of D2 and D13. The appellant further had the opportunity to present arguments orally in connection with the said combinations of documents if he had so wished, all the more so since D2, D3 and D13 were discussed individually at the oral proceedings.

For these reasons, the board considers that the right to be heard has not been violated. It follows from the above that no substantial procedural violation has occurred. Reimbursement of the appeal fee is therefore refused.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the opposition division with the order to maintain the patent with claims 1 to 12 of the main request submitted during the oral proceedings and the description to be adapted.

3. The request for reimbursement of the appeal fee is refused.

The Registrar: The Chairman:

P. Martorana R. Spangenberg