

Description

This invention relates to an assembly comprising an array of photo-sensitive members and a mask for partially shading a selected photo-sensitive member from radiation generally impinging on the array, the mask including support means and a bridge member which is coupled to said support means and which allows a portion of the radiation to impinge on the selected photo-sensitive member.

Spectrophotometers are instruments used to determine the chemical make-up of a sample by analyzing the spectral intensities of light directed through the sample. The light is divided into its component parts by the spectrophotometer, which then makes photometric measurements to determine which spectral components of the light source have been absorbed by the sample.

The light can be divided into its component parts by using a variety of devices, such as prisms, diffraction gratings, holograms, etc. The divided light tends to separate into spatially separated spectral bands which are arranged in the order of their frequencies. By analyzing the relative intensities of the spectral bands, the chemical nature of the sample can be deduced.

The intensity of the spectral bands can be measured by moving a photoelectric detector sequentially through the spectral bands, or by causing the spectral bands to move across a fixed detector. However, such methods are slow and requires precision transport mechanisms. A more desirable detector for use in spectrophotometers is a photodiode array comprising several hundred individual photodiodes formed on a common, semiconductor substrate. Each of the photodiodes of the array can correspond to a particular spectral band, allowing the intensities of all of the spectral bands to be measured simultaneously.

A problem with prior art photodiode array spectrophotometers is that a photodiode of the array can be overloaded if a particularly intense spectral band falls upon it. For example, it has been found that the light emitted by a deuterium discharge lamp source has a strong spectral line at 656 nanometers (nm) which can overload the photodiode corresponding to that wavelength and thus the analog-to-digital (A/D) converter which couples the photodiode array to the remainder of the system.

The aforementioned problem has been addressed by the Hewlett-Packard Company of Palo Alto, California with their models HP 8451 and HP 8452 diode array spectrophotometers. The solution with both the HP 8451 and HP 8452 is to apply an opaque mask over the photodiode array to partially shade the photodiodes corresponding to the strong

spectral bands.

As will be discussed in greater detail subsequently, the prior art photodiode array masks tend to introduce aberrations in the absorption curve generated by the spectrophotometer. These aberrations have been a persistent problem in the industry. For example, the Hewlett-Packard Company has been shipping spectrophotometers using the prior art photodiode array masks since approximately 1979, and has made continuing efforts to solve the problem of the aberrations caused by the prior art masks. Despite major research efforts by recognized experts in the field of spectrophotometry, the solution to this problem heretofore eluded discovery.

SUMMARY OF THE INVENTION

A major object of this invention is to provide a mask for a photodiode array which minimizes aberrations in the derived absorbance curve.

In accordance with the invention, in the assembly to which the invention relates, the bridge member partially overlies a photo-sensitive member or members adjacent the selected photo-sensitive member to prevent the radiation from impinging thereon.

In a preferred embodiment of the invention, the mask includes a frame provided with a slot for receiving a linearly arranged photodiode array. The bridge portion extends across the slot to shade a selected photodiode corresponding to a strong spectral band. The bridge portion has a lateral dimension which exceeds the lateral dimension of the selected photodiode to partially overlap portions of adjacent photodiodes. An aperture is provided through the bridge portion to permit a portion of the light corresponding to the strong spectral band to impinge upon the selected photodiode.

A major advantage of the invention is that it greatly decreases aberrations in the absorbance curve caused by photodiode masks of the prior art.

An embodiment of the invention will now be described with reference to some of the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a top plan view of a prior art photodiode array and mask assembly;

Fig. 2 is a partial cross-sectional view of the prior art assembly which is taken along line 2-2 of Fig. 1;

Fig. 3 is a diagram illustrating the absorbance curve produced by the prior art assembly of Fig. 1;

Fig. 4 is a top plan view of an improved photodiode array and mask assembly in accor-

dance with the present invention;

Fig. 5 is a partial cross-sectional view taken along line 5-5 of Fig. 4;

Fig. 6 is a diagram illustrating the absorbance characteristics of the photodiode array and mask assembly of Fig. 4; and

Figs. 7-9 illustrate a method for making an improved mask in accordance with the present invention, where:

Fig. 7a is a top plan view of a blank frame;

Fig. 7b is a cross-sectional view taken along line 7b-7b of Fig. 7a;

Fig. 8a is a top plan view illustrating a chemical etching step;

Fig. 8b is a cross-sectional taken along line 8b-8b of Fig. 8a;

Fig. 8c is a cross-section of a portion of Fig. 8a encircled by line 8c which illustrates an EDM machining step;

Fig. 9a is a top plan view illustrating the application of an absorptive coating to the mask; and

Fig. 9b is a cross section taken along line 9b-9b of Fig. 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In Fig. 1 a prior art photodiode array and mask assembly includes a photodiode array 10 having a substrate 12 and a plurality of linearly arranged photodiodes 14, and an opaque mask 16. The mask 16 includes a pair of frame portions 18 and 20 flanking a slot 21, a bridge portion 22 extending across slot 21, and protuberances 24 and 26 extending into slot 21.

During operation of the prior art spectrophotometer, sampled light source is split into a large number of spectral bands, at least some of which are focussed on individual photodiodes 14. For example, a narrow bandwidth of frequencies around 656 nm can be focused on a photodiode 14a, while a narrow bandwidth of frequencies around 654 nm and 658 nm can be focused on photodiodes 14b and 14c, respectively.

In this prior art solution, the bridge portion 22 of mask 16 partially shades photodiode 14a from light at 656 nm. Likewise, protuberances 24 and 26 partially shield a photodiode 14d from a portion of the incident light at a different frequency. By reducing the amount of light impinging on photodiodes exposed to light corresponding to strong spectral bands, the A/D converters which are connected to the photodiode array 10 are not overloaded. Unfortunately, it has been found that masking portions of individual photodiodes in a photodiode array can cause the aforementioned unwanted aberrations in the absorbance waveform.

With reference to Fig. 2, the aberrations produced by the prior art solution is believed to be caused, in part, by the reflection of light from the sides of the bridge portion 22 onto adjacent photodiodes. More specifically, a focused beam of light representing the spectral band centered at 656 nm is focused on photodiode 14a. The narrow bridge 22 partially shades photodiode 14a to produce a penumbra 30 over the majority of the surface of photodiode 14a. However, a portion of light 28 is reflected from the sides from bridge portion 22 as indicated by arrows 32 and 34. If the beam of light 28 shifts as indicated at 28' or 28" due to temperature fluctuations or other factors, the reflections 32 and 34 to adjacent photodiodes 14b and 14c, respectively, can be even more pronounced.

The result of the reflection off of the sides of bridge 22 with the prior art mask 16 can be seen in the absorbance waveform shown in Fig. 3. A smooth absorbance curve 36 is indicated in broken lines. The actual absorbance curve has a pair symmetrical pair of aberrations 38 and 40 centered around 656 nm. The aberrations 38 and 40 appear to be the derivatives of a delta function occurring at 656 nm.

Referring to Fig. 4, a photodiode array 42 in accordance with the present invention includes a substrate 44 and a number of photodiodes 46. A mask 48 in accordance with the present invention includes a pair of frame portions 50 and 52 flanking a slot 53, and a bridge portion 54 extending over the slot 53. An aperture 56 is provided through bridge 54 in alignment with a photodiode 46a.

With additional reference to the cross-sectional view of Fig. 5, the width W_b of bridge portion 54 is greater than the width W_d of the photodiodes 46. Also, the length L_b of bridge 54 is greater than the length L_d of the photodiodes 46. In consequence, photodiode 46a is substantially completely covered, with the exception of a small area beneath aperture 56.

Furthermore, the lateral width W_b of bridge 54 is sufficiently large to cover portions of adjacent photodiodes 46b and 46c. In other words, the width W_b of the bridge 54 is greater than the sum of the lateral widths W_d of the photodiodes 46 and twice the lateral separation "s" between adjacent photodiodes 46.

Referring now more particularly to Fig. 5, when a beam of light 58 corresponding to a particular spectral band (for example, 656 nm) impinges upon bridge 54, the photodiode 46a is substantially completely shaded from the light 58 with the exception of a small portion 60 of the beam of light 58 which travels through aperture 56. It should be noted that adjacent photodiodes 46b and 46c are substantially completely shaded from beam 58 due

the lateral extension of bridge 54. Furthermore, the 656 nm spectral band is blocked from the adjacent photodiodes even if light 58 shifts slightly laterally as indicated at 58' and 58".

It should also be noted that the cross-section of the aperture 56 does not have to be round, but can be of virtually any shape which permits the desired amount of light to impinge upon the photodiode 46a. Furthermore, it may be desirable in some circumstances to provide more than one aperture 56 through the bridge 54.

With the photodiode array and mask assembly shown in Figs. 4 and 5, the absorbance waveform as illustrated in Fig. 6 is much improved. A smooth absorbance curve 62 is illustrated in broken line, while the actual absorbance curve is indicated in a solid line. While the absorbance curve still includes a small aberration 64 centered around 656 nm, it is much smaller than the aberrations of the prior art. Furthermore, the aberration 64 takes the form of a delta function, rather than the form of the highly disruptive derivative of a delta function as experienced in the prior art.

A method for producing a photodiode array mask in accordance with the present invention will be discussed with reference to Figs. 7-9. It should be noted that, by necessity, the various figures are not to scale. For example, the thickness of the sections of Figs. 7-9 have been greatly exaggerated so that various features can be seen.

Referring to Figs. 7a and 7b, a mask is made by applying a thin layer of photoresist 66 to a metal blank 68. The blank is preferably rectangular in shape, and is typically on the order of .05 millimeters thick. The photoresist 66 is then exposed through a patterned reticle, and unwanted portions of the photoresist are removed. The blank 68 is next chemically etched ("milled") through the patterned photoresist layer 66.

Figs. 8a and 8b illustrate the frame 68 after the photoresist has been removed. The chemical etching produces an elongated slot 70 which essentially divides frame 68 into a pair of frame portions 72 and 74. The chemical etching leaves a bridge portion 76 which extends across slot 70 between frame portions 72 and 74.

Fig. 8c is an enlarged, cross-sectional view of the area encircled by broken line 8c of Fig. 8a. Preferably, aperture 78 is produced with a slightly conical electrode 80 attached to an electric discharge machine (EDM). An electric potential is developed between electrode 80 and bridge portion 76, and the electrode is slowly moved through the bridge portion 76 to form the aperture 78. Alternatively, an aperture through bridge 76 could be produced by the chemical etching which produced the slot 70, although it would be difficult to produce an aperture with a round cross-section by chemical

etching methods.

As seen in Figs 9a and 9b, after the aperture 78 has been made through the bridge portion 76, an absorptive covering 82 is applied to frame 68 to minimize reflection. The absorptive covering 86 can be applied by any number of conventional techniques, such as painting, anodizing, etc. Finally, the completed mask is applied to a photodiode array such that slot 70 is in alignment with the array and the bridge portion 76 is aligned with a predetermined photodiode of the array.

While this invention has been described with reference to a particular preferred embodiment, it is contemplated that various alterations and permutations of the invention will become apparent to those skilled in the art upon a reading of the preceding descriptions and a study of the drawing. It is therefore intended that the scope of the present invention be determined by the following appended claims.

Claims

1. An assembly comprising an array (42) of photo-sensitive members (46) and a mask (48) for shading part of a selected photo-sensitive member (46a) from radiation (58), an unshaded part of the array (42) receiving a portion (60) of said radiation (58), the mask (48) including support means (50, 52) and a bridge member (54) which is coupled to said support means (50, 52) and which shades said part of the selected photo-sensitive member (46a) from said radiation (58), characterised in that the bridge member (54) partially overlies a photo-sensitive member or members (46b, 46c) adjacent the selected photo-sensitive member (46a) to prevent said radiation (58) from impinging thereon.
2. A mask (48) according to Claim 1 further characterised in that said bridge member (54) is provided with an aperture (56) permitting a portion (60) of said radiation (58) to impinge upon said selected photo-sensitive member (46a).
3. A method for making the mask (48) in the assembly according to Claim 2 characterised by the steps of forming an elongated slot (70) in a blank (68) such that there is a bridge portion (76) extending across said slot (70), and forming an aperture (78) through said bridge portion (76).
4. A method according to Claim 3 wherein said slot (70) is produced by a chemical etching process.

the lateral extension of bridge 54. Furthermore, the 656 nm spectral band is blocked from the adjacent photodiodes even if light 58 shifts slightly laterally as indicated at 58' and 58".

It should also be noted that the cross-section of the aperture 56 does not have to be round, but can be of virtually any shape which permits the desired amount of light to impinge upon the photodiode 46a. Furthermore, it may be desirable in some circumstances to provide more than one aperture 56 through the bridge 54.

With the photodiode array and mask assembly shown in Figs. 4 and 5, the absorbance waveform as illustrated in Fig. 5 is much improved. A smooth absorbance curve 62 is illustrated in broken line, while the actual absorbance curve is indicated in a solid line. While the absorbance curve still includes a small aberration 64 centered around 656 nm, it is much smaller than the aberrations of the prior art. Furthermore, the aberration 64 takes the form of a delta function, rather than the form of the highly disruptive derivative of a delta function as experienced in the prior art.

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Referring to Figs. 7a and 7b, a mask is made by applying a thin layer of photoresist 66 to a metal blank 68. The blank is preferably rectangular in shape, and is typically on the order of .05 millimeters thick. The photoresist 66 is then exposed through a patterned reticle, and unwanted portions of the photoresist are removed. The blank 68 is next chemically etched ("milled") through the patterned photoresist layer 66.

Figs. 8a and 8b illustrate the frame 68 after the photoresist has been removed. The chemical etching produces an elongated slot 70 which essentially divides frame 68 into a pair of frame portions 72 and 74. The chemical etching leaves a bridge portion 76 which extends across slot 70 between frame portions 72 and 74.

Fig. 8c is an enlarged, cross-sectional view of the area encircled by broken line 8c of Fig. 8a. Preferably, aperture 78 is produced with a slightly conical electrode 80 attached to an electric discharge machine (EDM). An electric potential is developed between electrode 80 and bridge portion 76, and the electrode is slowly moved through the bridge portion 76 to form the aperture 78. Alternatively, an aperture through bridge 76 could be produced by the chemical etching which produced the slot 70, although it would be difficult to produce an aperture with a round cross-section by chemical

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While this invention has been described with reference to a particular preferred embodiment, it is contemplated that various alterations and permutations of the invention will become apparent to those skilled in the art upon a reading of the preceding descriptions and a study of the drawing. It is therefore intended that the scope of the present invention be determined by the following appended claims.

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2. A mask (48) according to Claim 1 further characterised in that said bridge member (54) is provided with an aperture (56) permitting a portion (60) of said radiation (58) to impinge upon said selected photo-sensitive member (46a).
3. A method for making the mask (48) in the assembly according to Claim 2 characterised by the steps of forming an elongated slot (70) in a blank (68) such that there is a bridge portion (76) extending across said slot (70), and forming an aperture (78) through said bridge portion (76).
4. A method according to Claim 3 wherein said slot (70) is produced by a chemical etching process.



5. A method according to Claim 4 wherein said chemical etching process includes the steps of:

applying a resist (66) to a surface of said blank (68);

exposing said resist (66) with a pattern of radiation;

developing said resist (66) to remove portions thereof producing a patterned resist layer on said blank (68);

chemically etching through said surface of said blank (68) where said resist (66) has been removed; and

removing the patterned resist layer.

6. A method according to any of Claims 3-5 wherein said aperture (78) is produced by electric discharge machining (80).

7. A method according to any of Claims 3-5 wherein said aperture (78) is formed by a chemical etching process.

8. A method according to Claim 7 wherein said aperture (78) is formed by the same chemical etching process which formed said slot (70).

Revendications

1. Un ensemble comprenant un réseau (42) d'éléments photosensibles (46) et un masque (48) pour protéger d'un rayonnement (58) une partie d'un élément photosensible choisi (46a), une partie non protégée du réseau (42) recevant une partie (60) dudit rayonnement (58), le masque (48) comprenant un moyen de support (50, 52) et un élément en pont (54) qui est accouplé audit moyen de support (50, 52) et qui abrite dudit rayonnement (58) ladite partie de l'élément photosensible choisi (46a), caractérisé en ce que l'élément en pont (54) recouvre partiellement un élément ou des éléments photosensibles (46b, 46c) adjacents à l'élément photosensible choisi (46a) pour empêcher ledit rayonnement (58) de le frapper.
2. Un masque (48) selon la revendication 1 caractérisé en outre en ce que ledit élément en pont (54) comporte un orifice (56) permettant à une partie (60) dudit rayonnement (58) de frapper ledit élément photosensible choisi (46a).
3. Un procédé de réalisation du masque (48) de l'ensemble selon la revendication 2 caractérisé par les étapes consistant à former une fente allongée (70) dans une ébauche (68) d'une manière telle qu'il existe une partie en pont (76) enjambant ladite fente (70) et à ménager

un orifice (78) à travers ladite partie en pont (76).

4. Un procédé selon la revendication 3 dans lequel ladite fente (70) est réalisée par un processus de gravure chimique.

5. Un procédé selon la revendication 4 dans lequel ledit processus de gravure chimique comprend les étapes consistant à:

appliquer une résine (66) à une surface de ladite ébauche (68);

exposer ladite résine (66) à l'aide d'une configuration de rayonnement;

développer ladite résine (66) pour enlever des parties en produisant sur ladite ébauche (68) une couche de résine configurée;

graver chimiquement à travers ladite surface de ladite ébauche (68) là où ladite résine (66) a été enlevée; et

enlever la couche de résine configurée.

6. Un procédé selon l'une quelconque des revendications 3 à 5 dans lequel ledit orifice (78) est produit par usinage par décharge électrique (80).

7. Un procédé selon l'une quelconque des revendications 3 à 5 dans lequel ledit orifice (78) est formé par un processus de gravure chimique.

8. Un procédé selon la revendication 7 dans lequel ledit orifice (78) est formé par le même processus de gravure chimique qui a formé ladite fente (70).

Patentansprüche

1. Anordnung mit einer Matrix (42) photo-empfindlicher Elemente (46) und einer Maske (48) zum Abschirmen eines Teils eines ausgewählten photo-empfindlichen Elementes (46a) gegen Strahlung (58), wobei ein unabgeschirmter Teil der Matrix (42) einen Teil (60) der Strahlung (58) aufnimmt, wobei die Maske (48) Unterstützungsmittel (50, 52) und einen Brückenteil (54) aufweist, welcher mit den Unterstützungsmitteln (50, 52) verbunden ist und den genannten Teil des ausgewählten photo-empfindlichen Elementes (46a) von der Strahlung (58) abschirmt, dadurch gekennzeichnet, daß der Brückenteil (54) teilweise ein oder mehrere photo-empfindliche Elemente (46b, 46c) überdeckt, welche benachbart dem ausgewählten photo-empfindlichen Element (46a) liegen, um die Strahlung (58) von einem Auftreffen darauf abzuhalten.



2. Maske (48) nach Anspruch 1, **dadurch gekennzeichnet**, daß der Brückenteil (54) mit einer Öffnung (56) versehen ist, welche einem Teil (60) der Strahlung (58) gestattet, auf das ausgewählte photo-empfindliche Element (46a) aufzutreffen. 5
3. Verfahren zum Herstellen der Maske (48) der Anordnung gemäß Anspruch 2, **gekennzeichnet** durch Bilden eines länglichen Schlitzes (70) in einem Rohling (68) derart, daß ein Brückenteil (76) geschaffen ist, der sich über den Schlitz (70) erstreckt, und Bilden einer Öffnung (78) durch das Brückenteil (76). 10
4. Verfahren nach Anspruch 3, bei welchem der Schlitz (70) durch ein chemisches Ätzverfahren erzeugt ist. 15
- Verfahren nach Anspruch 4, bei dem das chemische Ätzverfahren die folgenden Schritte aufweist: 20
- Aufbringen einer Resistschicht (66) auf eine Oberfläche des Rohlings (68);
 - Aussetzen der Resistschicht (66) einer Strahlung mit einem Strahlungsmuster; 25
 - Entwickeln der Resistschicht (66) zum Entfernen von Teilen davon, um eine gemusterte Resistschicht auf dem Rohling (68) auszubilden; 30
 - chemisches Ätzen durch die Oberfläche des Rohlings (68) dort, wo das Resistmaterial (66) entfernt worden ist; und
 - Entfernen der gemusterten Resistschicht. 35
6. Verfahren nach einem der Ansprüche 3 bis 5, bei dem die Öffnung (78) durch Bearbeiten mittels elektrischer Entladung (80) erzeugt wird. 40
7. Verfahren nach einem der Ansprüche 3 bis 5, bei dem die Öffnung (78) durch ein chemisches Ätzverfahren erzeugt wird. 45
8. Verfahren nach Anspruch 7, bei dem die Öffnung (78) durch dasselbe chemische Ätzverfahren erzeugt wird, welches zum Erzeugen des Schlitzes (70) eingesetzt wurde. 50

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