

DEVICE FOR MEASURING THE THICKNESS OF THIN COATINGS

The invention relates to an apparatus for measuring the layer thickness of thin coatings on objects and which operates by the X-ray absorption method. Such a device is described, for example, in German Published Specification No 32 39 379. Here, it is possible to look through the viewing microscope 78 and observe the underside 92 of the coating 93 which is illuminated by a light source 94. The coating lies on a working plate 18 which can be moved in the direction 24 and/or 26 by a precision transmission 27, 29. The working panel 18 is relatively small. Relatively large objects would hang down below the working panel 18 and would not have a rugged support because the panel 17 is of course lower down than the working panel 18.

The coating can also move while one is working on the instrument table, if something falls against the table or if by chance a garment fouls the device or the latter is struck by the knee of by a chair falling over or suffers similar mishaps.

It can, however, also happen that the object to be measured is in itself left at rest but that the object will in course of time creep or internal stresses may become noticeable so that the object moves like a transparency and so alters its position.

The device is not suitable either for the rapid and thus favourably costed viewing of printed circuit boards which have to be pushed quickly back and forth over the

clearance hole. The orientation as to which area is aligned with the geometrical longitudinal axis 32 is carried out by a single eye since a stereomicroscope would be too expensive. If the object to be measured is moved quickly, then the eye tires within a short time.

An object of the invention is to provide an apparatus which makes it possible quickly, accurately to position test objects of relatively large extension without fatigue and in an easy manner, particularly in the case of printed circuit boards, so that where these are concerned, for example the through-contact can easily be found, positioned and held securely throughout the period of the test.

According to the invention there is provided an apparatus for measuring the layer thickness of thin coatings on objects to be measured and which operates by the X-ray method, comprising means for observing that area of the surface of the thin coatings through which the geometrical central axis of the X-rays passes, a table for supporting the objects to be measured, said table extending substantially at a right-angle to said central axis and having a cut-out around the central axis, illuminating means beneath the table for lighting the surface through the cut-out, image detecting means located in the path of the light rays above the table and having an output for connection to a video display unit, a depressor means adapted for upwards and downwards movement in relation to the table located above the cut-out, said depressor means being movable to an upper position at least high enough that the object to be measured can be pushed between its pressure applying face and the table and to a lower position to apply force to press the object to be measured against the top of the table and hold it in a non-positive manner, and means for controlling the vertical position of the depressor means, the pressure-applying surface of said depressor means surrounding the central axis.

By means of the present invention there is no longer

any need to hold the eye up to the eyepiece 79 according to the state of the art. Instead, the head can be held over the table. In this respect, "table" denotes an apparatus of relatively large area compared with "plate", "small table", "support" or the like.

It is now possible to watch an image screen with both eyes, in other words without tiring, and it is no longer necessary either to position the eye within one definite region in relation to the eyepiece in order to view the area of measurement.

Preferably the table is at least 400 sq cm which means that, statistically seen, the object to be measured does not always project beyond the edge of the table so that moving it about on the table by hand is also easier. Furthermore, the table does not require any fine adjustment.

While it is in its upper position, the depressor means provides for a rapid search facility on the image screen. In this respect, the image screen preferably provides a view corresponding to that in Figure 6 of the above-mentioned Published Specification, which remains stationary while the object to be measured is moved in relation thereto. When the depressor means is in the lowered condition, it holds the test object sufficiently accurately but without damaging it. If the switch is a foot switch, then - without releasing the said object - the depressor means can be lowered so that positioning is possible even more quickly and accurately and even less tendency to cause fatigue.

Since the illuminating device is directed at the aperture, this provides an approximate positioning because for instance the light shimmers through printed circuits. It is possible to see approximately which area of the test object is disposed above the opening in the table, the coarse positioning is rapid. The light is used not only to illuminate the area under test, but also for positioning purposes.

Suitable dimensioning of the pressure-applying surface around the central axis so that the distance between the pressure-applying surface and the axis is less than the distance of the edge of the table to the axis means that specific areas of the depressor can remain small and that above all the pressure-applying effect does not vary towards the geometrical central axis, which would be the case if the pressure-applying face were to act farther out.

By making the cut-out in the table larger than the X-ray beam means that in the case of printed circuits or other translucent objects which are to be measured, a sufficiently large spot of light is formed on the upper side (which does not have to be measured) of the object under test.

As a result of the features disclosed in claim 2, a CCD camera is provided which is flat, long-lived and generates little heat.

As a result of the features disclosed in claim 3, a major part of the optics known from the state of the art can be easily incorporated and the device can be basically left as it is. The device then forms one unit together with the electronic eye.

As a result of the features in claim 4, a fixed relationship is obtained between image screen and device, which can if necessary be transported with each other and after possible dismantling or reconstruction, the same configuration is quickly regained. It is possible to manage with only a small space and no special laboratory tables are required.

The features according to Claim 5 provide a table which is of optimum size, without the overall contours of the device being larger. Such a construction is space-saving and means that other instruments can be set up close by.

5 As a result of the features according to Claim 6, once it has been applied, the force of the pressure applied does not shift the location of the test object.

10 The features according to Claim 7 mean that the test object is only supported spotwise, which ensures a reliable location of the test object. Many objects such as, for example, printed circuits, do of course have projecting areas of surface and the raised areas prevent the object wobbling when held.

15 The features according to Claim 8 protect those areas of the test objects and prevent the test object fouling the raised portions when it is being moved about.

20 As a result of the features according to Claim 9, it is possible easily to push even relatively heavy objects back and forth for test purposes. The friction between the balls and the object being tested is low so that the danger of the object being damaged while it is being moved is also low.

The features according to Claim 9 on the one hand provide for sufficiently high raised portions, while on the other the ball cups can be reliably guided in the table.

25 The features according to Claim 11 mean that the areas of

the object to be measured can be subjected to a symmetrical loading by the applied force around the central axis, so that if any sag or deflections occur, they will at most be symmetrical but never one-sided.

- 5 In consequence of the features according to Claim 12, the force of the applied pressure is best absorbed where it occurs, whereas the areas with fewer raised portions serve only to facilitate displacement of the object being measured.

- 10 The features according to Claim 13 prevent any dirt which may arise during displacement of the objects to be measured from falling down into the device.

The features according to Claim 14 prevent any splinters occurring on the table; it can easily be kept clean and the material is self-lubricating.

- 15 The features according to Claim 15 provide a material which is to an optimum degree compatible with the table material and which also offers the advantages thereof.

- 20 In consequence of the features according to Claim 16, anyone can see whether any dirt is present on the film and it is possible to see whether the film is in the right position, and it is also possible to see with the naked eye the spot of light shining through the object to be tested.

The features according to Claim 17 provide a rigid, easily constructed component element of which the properties are

readily foreseeable and which can above all trap stray radiation which may occur as secondary radiation. In spite of this, once can see into the area of measurement.

5 The features of Claim 18 make it possible to trap X-rays irradiated in the direction of the central axis, without this influencing the side wall.

By virtue of the features according to Claim 19, above all the core of the X-rays can be trapped especially well through the thick-walled cup.

10 As a result of the features according to Claim 20, it is also possible to trap those X-rays which diverge like a paintbrush and the trapping device nevertheless remains light, if the main mass of the absorbing material is absorbed in the cup and if the disc which is then made thinner is
15 also used at the same time to support the top wall of the bell.

It is also possible for the disc to hold the cup. The thin disc does not interfere with the view if one looks obliquely downwards and the cup which projects relatively far downwardly does not interfere because it does not mask the opening in the direction of view.
20

According to the features of Claim 22, the glass does not shatter which might be the case with organic glass due to unevennesses of the objects to be measured, and which might also be the case on a basis of the force of the applied

pressure. Furthermore, the bell need not then be placed so gently on the object to be measured.

The features according to Claim 23 afford the best view into the bell.

- 5 By virtue of the features according to Claim 24, narrow, strip-like objects can also be measured, optimum positioning by the bell being feasible.

A support arm according to Claim 25 interferes neither with working nor with the view of the image screen.

- 10 The features according to Claim 26 give rise to a frictional connection within the device in respect of the force of the applied pressure.

A particularly favourable fitment is afforded by Claim 27, causing minimal interference and being very flexurally rigid.

- 15 The features according to Claim 28 mean that the table can be loaded from both sides and from the front in the same way, the retaining forces being symmetrically accommodated.

In itself, the supporting arm could also be moved up and down. A substantially mass-free movement is, however,

- 20 obtained as the result of Claim 29. The movement per se could also be generated by a manually actuated transmission. A pneumatic or hydraulic movement would also be conceivable. The solution indicated here is, however, the simplest since it diverges least from viewing and two-handed movement of the

the object to be measured, the voltage for the electro-magnet being derived from the input transformer which is provided in any case.

The transmission is most simplified by the features of
5 Claim 30. Certainly, then, the electro-magnet is positioned in front of the supporting arm. The electro-magnet could also be accommodated in the supporting arm and in this case, the transmission is a force-deflecting lever arrangement.

By reason of the features according to Claim 31, it is
10 possible to move the bell into that position which is most suitable for measurement purposes. This, for example, if the bell is not equally transparent at all its locations or if the bell has marginally open cut-outs to accommodate strip-like objects which are to be tested.

15 The features according to Claim 32 make it possible to prevent the test object and the bell performing creeping movements after the pressure-applying force is applied.

The features according to Claim 33 permit of a little readjustment.

20 The invention will now be described with reference to a preferred embodiment with reference to the accompanying drawings in which:

FIGURE 1 shows the device viewed from the operating side;

Fig. 2 shows a plan view of Fig. 1 without the image screen;
Fig. 3 shows the device in Fig. 1, viewed from the right;
Fig. 4 shows the device in Fig. 1, viewed from the rear;
Fig. 5 shows an enlarged plan view of an area of the table
5 indicating the bell, and
Fig. 6 shows an enlarged view in the region of the central
axis, partly in section.

A rugged instrument casing houses an instrument for measuring the thickness of thin coatings by the X-ray absorption
10 principle. Instruments of this type are available from various manufacturers. One of them is described, for example, in German Published Specification No. 32 39 379. Where that specification discloses a viewing microscope device
15 78, here there is a component casing 12 containing an electronic eye which records the image which the eye would otherwise register. As Fig. 3 shows, the element casing 12 extends for quite a distance leftwards.

From the element casing 12, a video line 13 extends internally to the back 14 of the instrument casing which leads
20 from there to an image screen apparatus 16 comprising an image screen 17. Provided on the back 14 are vertically extending ribs 18. Fixed to these is a frame, not shown, which holds the image screen apparatus 16 in a spatial position shown in Fig. 1 so that a person whose bent forearms
25 are approximately at the height of a table 19 can look straight at the image screen 17. When the device is switched on, there appear on the image screen 17 intersecting

reference lines as shown in Fig. 6 in the state of the art. If a printed circuit is placed on the table 19, then one sees in a substantially enlarged view also the under side of this printed circuit 21. Measurement then takes place
5 according to the location and size of the through-bores 58, 59, 61, 62, 63 (these reference numerals from the state of the art) within the square shown in Fig. 6.

The light needed to operate the electronic eye emanates, in the case of the present invention, from a light source
10 similar to the light source 94 used therein.

Provided on the top of the instrument casing 11, in its four corner areas, are rotatable threaded screws 22 which support the table 19 in the regions located above them. According to how far and in what direction the threaded
15 screws 22 are turned, so the location of the table can be adjusted.

The area of the table is substantially larger than the top of the instrument casing 11. In particular, it projects sufficiently far beyond the front 23 that the assembly
20 casing 12 is covered at the top so that not only is table area gained but also the assembly casing 12 is protected (see Fig. 3).

The table 19 also projects considerably beyond the right-side 24 of the instrument casing 11 so that sufficient sur-
25 face area is obtained to the right of a cut-out 26 in the table 19. As can be seen particularly in Fig. 2, the cut-out

26 is relatively far forwards and on the right in relation to the instrument casing 11 and the table overhangs compensate for this substantially.

The table 19, which preferably has an area in excess of 400 sq cm, consists of a relatively thin bottom panel 27 of polyamide material and an upper panel 28 which is substantially thicker than this, both panels being bolted together in a manner not illustrated, in such a way as to form a single table.

Provided in the upper panel 28 are frustoconical bores 29 which extend through it upwards and of which the larger diameter is adjacent the lower panel 27 while their smaller diameter merges into the top surface 31 of the upper panel 28. These bores 29 are closed at the bottom by the lower panel 27. Located in the bores 29 are balls 32 of polyamide material, all the balls being of the same size and being of such a fit that the balls 32 can rotate. The shape of the bores 29 is such that the balls 32 have a top portion 33 extending above the top surface 31, the height of the ball above the surface 31 being about one-fifth of the ball diameter.

As Figure 5 shows, the number of balls in the area around the cut-out 26 is greater than in those areas which are remote from the cut-out. Furthermore, the balls 34, 36, 37, 38 are so located they are in pairs symmetrical to the geometrical central axis 39 which corresponds to the geometrical longitudinal axis 32 known from the state of the art.

As Figure 5 shows, the cut-out 26 is oval in shape. The oval central point lies, however, likewise in the geometrical central axis 39.

Provided in the lower panel 27 and starting from the front edge 41 of the table there is an open topped drawer-like recess 42 of which the bottom is flat and the side walls 43, 44 are straight and extend parallel with each other, extending a little beyond the cut-out 26 (Fig. 5).

Provided both in the lower panel and also in the upper panel 28 is a handle recess 46 in the region of the recess 42 and extending from the front edge 41. Provided behind the handle recess 46 is a throughbore 47 in which fits a screw 48.

10 In the recess 42 there is a synthetic plastics slide 49 of rectangularly elongate form and which fits the recess 42. It can be drawn out in a straight line frontwards from the recess 42 once the screw 48 has been removed. In the region of the recess 26, the slide 49 has a rectangularly elongate
15 recess 51, the area of which is substantially greater than the recess 26 and the central point of which is also the geometrical central axis 39. The recess 51 accommodates an approximately 20 μ m thick film 52 of Mylar (Registered Trade Mark of DuPont). The film 52 does not interfere with
20 the X-rays and is virtually no hindrance to the light source, not shown, which shines from the bottom into the recess 26. However, it does prevent dirt dropping down. Dirt can be removed by pulling out the slide 49.

25 Fixed on the back 14 of the instrument casing 11 on the ribs 18 by screws is a rigid curved bracket 53. In its (according to Fig. 2) right-hand zone is fixed an overhanging arm 54 which is bent in one piece from a flexurally rigid metal

tube the fixing arm 56 extending vertically upwards from the curved bracket 53 and then, after making a 90° bend, merging into a supporting arm 57 which extends parallel with the table 19 from which it is spaced by a comparatively small distance and which, extending rearwards, reaches not quite as far as the geometrical central axis 39.

Electrical conductors 58, 59 extend through the overhanging arm 54. The conductor 58 (a twin core conductor) goes to a foot switch 61 with a foot plate while the conductor 59 goes to the instrument casing 11.

With the foot switch 61 it is possible via the conductor 59 to operate an electromagnet 62 which, at the free end of the supporting arm 57, is rigidly mounted so that its geometrical longitudinal axis is aligned with the central axis 39. If the foot switch 61 is depressed, then the armature (not shown) of the electromagnet 62 moves into its bottom position. If the foot switch 61 is released, then the armature moves into its upper position. The location of the armature is made known via the conductor 59 to the instrument casing 11 so that it is informed of whether it is possible to measure or not.

Emerging from the bottom of the electromagnet 62 is a rod 63 at the bottom end face of which there is a plate 64 which is of sheet iron and a few millimetres thick. It is circular and its diameter according to Fig. 5 goes far beyond that of the cut-out 26. Screwed from the under side

against the plate 64 is an open-bottomed cup 66 which is likewise coaxial with the geometrical central axis 39 and which consists of iron; it has a coaxial screw (not shown) which at the same time also secures the plate 64 to the rod 63.

5 The rod 63 also carries a bell 67 of glass-clear acrylic material. Its top 68 ~~is situated~~ above the plate 64. The top 68 is rigid in an axial direction but is (like the plate 64 and the cup 66) rotatably connected to the rod 63.

Outwardly, the top 98 merges at a right-angle into a circularly cylindrical side wall 69 which projects downwardly and which is coaxial in relation to the geometrical central axis 39. This produces the open-bottomed bell 67 which has at the bottom a circular end face 71. Offset by in each case 180° there is machined into the bottom a relatively
10 broad but flat downwardly marginally open cut-out 72 and, offset by 90° thereto, there is also machined a relatively
15 narrow but higher cut-out 73.

In the upper location of the rod 63 the end face 71 is considerably above the position shown in Fig. 6, so that the
20 printed circuit 21 can be pushed back and forth freely over the cut-out 26. In the position shown in Fig. 6, the end face 71 exerts a force on the top of the printed circuit 21 which is then absorbed by the apex of the relevant ball cups 33 and then by the lower panel 27.

25 In operation, the printed circuit 21 is pushed into the

desired position while one is watching the image screen 17. As it is pushed back and forth, the under side 74 of the printed circuit 71 is still not sharply depicted in the electronic eye and a somewhat unfocused image will accordingly appear on the screen 17. However, this is sufficient to determine approximately which area of the geometrical central axis 39 is being traversed. If the foot switch 61 is then depressed, then the underside 74 is applied in a definite manner against the tops of the balls 32 and the plane defined thereby is then the sharp image plane. The image screen 17 now shows sharply that area which is around the geometrical central axis 39. If the visible area is not exactly in the area to be measured, then with increased but nevertheless still minimal application of force, the printed circuit 21 can be pushed on by the small amount necessary while the bell 67 is still depressed.

CLAIMS:

1. An apparatus for measuring the layer thickness of thin coatings on objects to be measured and which operates by the X-ray method, comprising means for observing that area of the surface of the thin coatings through which the geometrical central axis of the X-rays passes, a table for supporting the objects to be measured, said table extending substantially at a right-angle to said central axis and having a cut-out around the central axis, illuminating means beneath the table for lighting the surface through the cut-out, image detecting means located in the path of the light rays above the table and having an output for connection to a video display unit, a depressor means adapted for upwards and downwards movement in relation to the table located above the cut-out, said depressor means being movable to an upper position at least high enough that the object to be measured can be pushed between its pressure applying face and the table and to a lower position to apply force to press the object to be measured against the top of the table and hold it in a non-positive manner, and means for controlling the vertical position of the depressor means, the pressure-applying surface of said depressor means surrounding the central axis.

2. An apparatus as claimed in claim 1, wherein the image detecting means is a CCD camera.

3. An apparatus as claimed in claim 1, wherein the image detecting means is attached to a fixed part of the



apparatus on the observation side of the table.

4. An apparatus as claimed in claim 1, wherein a video display unit is mounted behind the table on a fixed frame being part of the apparatus.

5. An apparatus as claimed in claim 1, wherein the overall contours of the table are at least as large as those of the device itself.

6. An apparatus as claimed in any one of claims 1 to 5, wherein the table is flexurally resistant to the force of the pressure applied.

7. An apparatus as claimed in claim 1, wherein the table has a plurality of upwardly projecting raised portions.

8. An apparatus as claimed in claim 7, wherein the raised portions have round tops.

9. An apparatus as claimed in claim 7, wherein the raised portions comprise the tops of balls contained in ball cups being depressions in the table which permit rotation of the balls and from which they extend.

10. An apparatus as claimed in claim 9, wherein the ball cups extend upwardly above the table by less than one-third of the ball diameter.

11. An apparatus as claimed in claim 7, wherein the raised portions provided close to the central axis are disposed symmetrically around the central axis.

12. An apparatus as claimed in claim 7, wherein more raised portions are disposed around the central axis than in the outer areas of the table.



13. An apparatus as claimed in any one of claims 1 to 12, wherein the cut-out traversed by the central axis is covered by a transparent film which does not adversely affect X-rays.

14. An apparatus as claimed in any one of claims 1 to 13, wherein the table consists of a polyamide material.

15. An apparatus as claimed in claim 14 when appended to claim 9, wherein the balls consist of the same polyamide material as that of the table.

16. An apparatus as claimed in any one of claims 1 to 15, wherein the depressor means allows a view of the opening.

17. An apparatus as claimed in claim 16, wherein the depressor means comprises a bell, the side wall of which is at least partially transparent.

18. An apparatus as claimed in claim 17, wherein the top wall of the bell has an X-ray trap.

19. An apparatus as claimed in claim 18, wherein the trap has a downwardly open cup coaxial with the central axis.

20. An apparatus as claimed in claim 18, wherein the trap has, coaxial with the central axis, a disc which at least partially covers the top wall.

21. An apparatus as claimed in claim 19 and 20, wherein the disc is mounted above the cup.

22. An apparatus as claimed in any one of claims 17 to 21, wherein the bell is of organic glass, of which the bottom end face is the pressure-applying surface, the end



face being perpendicular to the central axis.

23. An apparatus as claimed in claim 22, wherein the glass is colourless and transparent.

24. An apparatus as claimed in claim 17, wherein according to the area, small recesses which extend upwardly are machined into the bottom end face of the bell.

25. An apparatus as claimed in claim 1, wherein the pressure-applying device comprises, extending above the table, a support arm which absorbs the force of the applied pressure.

26. An apparatus as claimed in claim 1, wherein the supporting arm is rigidly connected to a fixed part of the apparatus.

27. An apparatus as claimed in claim 25, wherein the support arm is a part of a gantry comprising a tube and a fixing arm is attached to a fixed part of the apparatus at the rear.

28. An apparatus as claimed in claim 25, 25 or 27, wherein the support arm extends centrally above the table and the fixing arm likewise extends centrally.

29. An apparatus as claimed in claim 25, wherein fixed on the free end portion of the support arm is an electro-magnet which drives a transmission for moving the depressor means between said upper and lower positions, the electro-magnet being movable into one or other position by a switch.

30. An apparatus as claimed in claim 29, wherein the



electro-magnet stands perpendicular and the transmission is a rod of which one end is connected to the armature of the electro-magnet while its other end is connected to the bell.

31. An apparatus as claimed in any one of claims 1 to 30, wherein the depressor means is adapted to rotate about its vertical axis.

32. An apparatus as claimed in any one of claims 1 to 31, wherein the pressure-applying surface of the depressor means is formed of hard material.

33. An apparatus as claimed in claim 1, wherein the force of the applied pressure is at most sufficiently great that even when it is present, a printed circuit or similar board-like object to be measured can be moved manually in the millimetre range in relation to the table.

34. An apparatus for measuring the layer thickness of thin coatings on objects to be measured and which operates by the X-ray absorption method, comprising means for observing that area of the surface of the thin coatings through which the geometrical central axis of the X-rays pass, means for supporting the objects which are to be measured on the device, the said support means extending substantially at a right-angle to said central axis and having a cut-out around the central axis, and illuminating means for lighting the surface through the cut-out, characterised by the following features:

a) image detecting means located in the path of the light rays on the observation side of the support means,



b) the image detecting means serves to control a video display unit,

c) the support means is a table having a surface area of at least 400 sq cm,

d) provided above the cut-out is a depressor means adapted for movement towards and away from the table, one position away from the table being at least far enough from the table for the object to be measured to be pushed between the pressure-applying face and the table and a position towards the table where the pressure-applying surface can apply force to press the object to be measured against the top of the table and hold it in a non-positive manner,

e) a switch is provided by which the depressor means can be moved into either of its two positions,

f) the pressure-applying surface extends around the central axis, the distance between it and the central axis being far less than the distance from the central axis to the edge of the table, and

h) the cut-out in the table is of sufficient area to permit passage of the X-ray beam.

35. An apparatus for measuring the layer thickness of thin coatings as claimed in claim 1 substantially as described with reference to the accompanying drawings.

