March 19, 1968 H. W. ALTER 3,373,683

VISUAL IMAGING OF TRACK-ETCHED PATTERNS

Filed Oct. 20, 1966

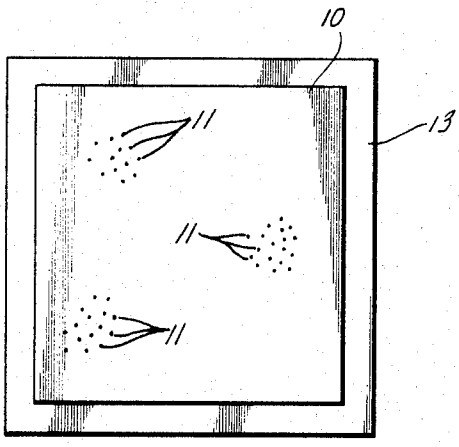


FIG. 1

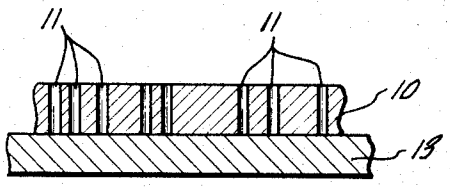


FIG. 2

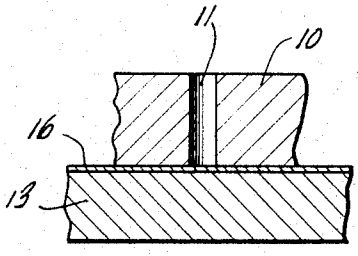


FIG. 4

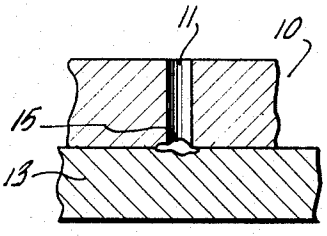


FIG. 3

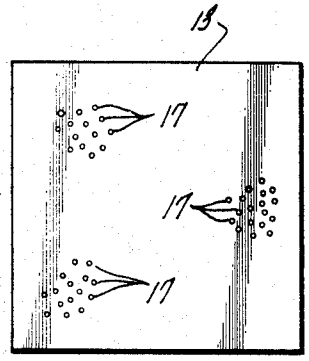


FIG. 5

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VISUAL IMAGING OF TRACK-ETCHED PATTERNS

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4 Claims. (Cl. 101—129)

ABSTRACT OF THE DISCLOSURE

A method of making very small track-etched holes through a sheet visible to the unaided eye is described. Briefly, the track-etched sheet is placed in contact with a receptor sheet and a marking fluid is forced through the holes to produce dots on the receptor sheet which are large and intense enough to be seen.

This invention relates to a method and apparatus for making a readily visible image of a pattern of microscopic holes in a sheet of track-etched material, and includes techniques for producing multiple images of a pattern of track-etched holes.

The invention is an extension of a known process which is usually called "track etching." A general description of the track-etching process appears at page A1443 of "Physical Review," volume 133, No. 5A (March 1964). The process is also described in copending patent applications Ser. No. 176,320, filed Feb. 28, 1962, now U.S. Patent 3,303,085 to Price and Walker and Ser. No. 368,520 (Price and Walker), filed May 19, 1964, now abandoned.

The track-etching process employs a homogeneous, solid-state detector material which may be a crystalline solid such as mica, or a non-crystalline substance such as inorganic glass or a polymeric plastic. The detector material is irradiated by charged particles, and damage tracks are created in the material by local alteration of the material structure along the particle trajectories or penetration paths. The damage tracks are extremely small (typically having lengths of about 20 to 40 microns, and widths of less than 100 angstroms), and normally can be detected only with the aid of an electron microscope. An etching process then enlarges the track width to 1–20 microns. Individual tracks are thus made visible to the optical microscope and, if the density of tracks is sufficiently high, the track-etched area is visible without magnification.

For example, a sheet of polycarbonate resin (such as plastic sold under the trademark "Lexan") or polyester resin will form damage tracks when irradiated by heavy fission fragments producted by bombarding materials such as uranium-235 or plutonium-239 with neutrons. A few materials such as cellulose nitrate will also form damage tracks along the paths traversed by alpha particles (produced, for example, by neurton bombardment of lithium-6 or boron-10). A suitable etching reagent, such as a six-normal aqueous solution of sodium hydroxide, is then applied to the detector material to dissolve the disordered regions which form the damage tracks.

It is a characteristic of the track-etching process that the etching reagent preferentially attacks the altered material along the damage track at a much faster rate than it attacks the undamaged material around the track. If the detector material is relatively thin (say 0.0005 inch), the damage tracks can extend through the sheet, and tiny holes are formed through the detector material as the etching process is carried out. Depending on the extent to which etching is carried out, these holes have widths in the range of say 1 to 20 microns, and are thus

visible with a conventional optical microscope. Individual holes, however, are too small to be readily detected without optical magnification, although a group of many closely spaced holes can be visually detected when the sheet of detector material is viewed by transmitted or reflected light.

In many applications of the track-etching process, it is desirable to detect quickly and inexpensively the presence and density of holes in the etched detector material, and to determine the pattern in which the holes are disposed. It is also desirable in certain applications to form duplicate copies or images of the hole pattern. For example, the track-etching process is useful in dosimetry (see "Applied Physics Letters," volume 3, No. 2, page 28, July 15, 1963), and in radiography (alpha-autoradiographs formed by this process are described in copending application Ser. No. 558,490, filed June 17, 1966). The track-etching process would be of greater utility in these applications if visual inspection and easy duplication of the hole patterns could be conveniently accomplished.

This invention provides visual images of track-etched hole patterns, and permits these images to be reproduced in multiple copies. Briefly stated, the method of this invention is carried out by positioning a sheet of receptor material in face-to-face contact with a track-etched sheet. A marking fluid is then applied to the exposed face of the track-etched sheet. The marking fluid flows through the track-etched holes into contact with the receptor sheet and is deposited in a pattern of dots on the receptor sheet to produce a visual image of the hole pattern. If duplicate copies are desired, the receptor sheet is stripped from the track-etched sheet, and the process repeated with fresh sheets of receptor material. Preferably, the receptor sheet includes a dye which reacts with the marking fluid to produce a distinct color change on the surface of the receptor sheet.

These and other espects of the invention will be explained in terms of the drawings, in which:

FIG. 1 is a plan view of a sheet of track-etched material positioned against a sheet of receptor material;

FIG. 2 is an enlarged side view, partly in cross section, of the sheets shown in FIG. 1;

FIG. 3 is an enlarged cross-sectional side view of the sheets showing a deposit of marking fluid on the receptor sheet;

FIG. 4 is an enlarged cross-sectional side view of the sheets showing a dye layer on the receptor material;

FIG. 5 is a plan view of a sheet of receptor material showing a visual image of the track-etched hole pattern.

Referring to FIGS. 1 and 2, a sheet **10** of track-etched material has been irradiated and etched to form three groups of holes **11** therethrough. The mechanics, materials and techniques of the track-etching process are known, and need not be described in detail. Sheet **10** can, for example, be a thin (say 0.0005 inch) sheet of polycarbonate resin, sold under the trademark "Lexan," which has been exposed to fission fragments emitted by an object containing zones of irradiated U-235 and subsequently etched to reveal the location of the U-235 in radiographic fashion. That is, track-etched holes **11** appear in clusters or groups corresponding in location to the fission-fragment-emitting U-235 zones in the object. It is to be understood that holes **11** are small, having diameters in the range of about 1 to 20 microns. If the density of the holes is sufficiently high, groups of holes can be visually detected when the sheet is positioned between a light source and the viewer, but there exists a need for a more sensitive method of making the hole patterns readily visible and reproducible.

To form a visual image of the track-etched hole pattern, sheet **10** is positioned in face-to-face contact with a sheet **13** of receptor material which can be metal, plastic

or paper. Preferably, the receptor material is slightly porous to provide a "blotting" action upon contact with a marking fluid.

With sheets **10** and **13** assembled in close contact, a marking fluid such as a low-viscosity ink is applied to the exposed face of sheet **10**. The ink is forced through holes **11** with a swab or roller, and flows through the holes to contact the surface of sheet **13** to form a deposit **15** on the surface of the receptor material. If a relatively porous receptor material such as paper has been selected, the marking fluid will flow radially beyond the confines of hole **11** as shown in FIG. 3 to form a visible deposit which is larger than hole **11**. This "amplification" is desirable as the enlarged deposits are readily visible without optical magnification. The ink is preferably in a color which contrasts sharply with the color of the receptor material.

FIG. 4 shows another form of the invention in which a layer **16** of an indicator dye such as phenolphthalein is coated on the surface of sheet **13** of the receptor material. A marking-fluid reagent is then applied to the exposed surface of the track-etched sheet in the manner described above, the reagent being chosen to produce a change of color in the dye layer. This configuration can be used as the track-etching process is being carried out, as most suitable etchants will react with the dye layer to produce a color change.

For example, sodium hydroxide is typically used as an etchant in the track-etching process, and this reagent produces a distinct color change in a phenolphthalein layer on the receptor material when a hole is etched through the sheet **10**. If holes have already been etched through sheet **10**, any suitable non-etching reagent may be used to form the visual image of the hole pattern on the dye layer which coats the surface of the receptor material. For example, an acid solution which is forced through the holes will cause a pink phenolphthalein indicator dye on the receptor sheet to become colorless where it is contacted by the acid. These specific combinations of fluids and receptor-sheet dyes or indicators are examples of several suitable reactions useful to form images. Other suitable reactions include coupling reactions between organic dyes, inorganic precipitation reactions, redox reactions (e.g., bleaching), and inorganic colored complex reactions such as the copper-ammonia complex.

The above-described processes can be repeated to produce multiple copies of the hole-pattern image. That is, a marked or dyed receptor sheet is easily stripped from the track-etched sheet, and replaced with a fresh receptor sheet to form duplicate copies. If separate hole-pattern images are not required, another form of the process can be used in which a dye is flowed into the holes to make readily visible the hole pattern in the track-etched sheet itself. Fluorescing dyes (such as used in the "Zyglo" non-destructive testing technique) are especially useful in this method, and the holes in a transparent sheet can be visually detected when filled with dye and viewed in fluorescent light.

FIG. 5 shows the appearance of the receptor material after completion of either of the above-described visual-imaging processes. Marks **17** on the receptor material correspond to either deposits **15**, or to those portions of dye layer **16** which have come in contact with a reagent. Marks **17** are disposed in the same pattern as holes **11** in track-etched sheet **10** as shown in FIG. 1, but are enlarged and colored to be readily visible without optical magnification. This visual "amplification" technique permits detection of even a single track-etched hole in sheet **10**, whereas only relatively high densities of holes (in the range of one-million holes per square centimeter) can be detected in the track-etched sheet itself when viewed by transmitted light.

I claim:

1. A method of producing a visual image of a pattern of holes through a sheet of track-etched material, comprising the steps of:

(a) positioning a sheet of receptor material having a porous surface in face-to-face contact with a track-etched sheet said track-etched sheet having a thickness of up to about 0.0005 inch and containing at least one hole having an average diameter of up to about 20 microns extending therethrough;

(b) applying a sufficient quantity of a marking fluid to the free surface of the track-etched sheet so that the fluid flows through the holes into contact with the receptor sheet, producing a pattern of visible dots on the receptor sheet each of said dots having an area greater than the cross-section of the corresponding hole; and

(c) stripping the receptor sheet from the track-etched sheet.

2. The method of claim **1** wherein steps (a) through (c) are repeated at least one additional time with at least one additional sheet of receptor material.

3. The method of claim **1** wherein the marking fluid is applied to the surface of the track-etched sheet until the dots on the receptor sheet have an average diameter substantially greater than 20 microns.

4. The method of claim **1** wherein the receptor sheet includes a dye which changes color on contact with a reagent and said marking fluid includes said reagent.

References Cited

UNITED STATES PATENTS

798,528 8/1905 Ostwald ---------- 101—129

OTHER REFERENCES

Korting, German App. No. 1,077,679, pub. March 1960, Cl 101/121, 1 sh. dwg., 1 p. spec.

Fluorescent Penetrant Inspection, Steel, vol. 115, No. 16, Oct. 16, 1944, pp. 100, 101, 102, 164. Copy in 250/71 T.

DAVID KLEIN, *Primary Examiner.*