[0031] FIG. **14** shows an SEM micrograph image of an AAO membrane with 40 nm intrinsic nanopores and 10 micrometer diameter patterned channels with a widened funnel-shaped channel entrance.

DETAILED DESCRIPTION OF EMBODIMENTS

[0032] Preparation of an MCP detector includes fabrication of an AAO membrane **10** (see FIGS. **1-3**). The membranes **10** can have a selectable range of nanopores **20**, such as for example, having about 10 nm to 500 nm pore diameters with selected separation distance, such as for example 20 nm to 1 micrometers. These nanopores **20** can then most preferably be coated by an atomic layer deposition (ALD) process to create a desired layer for the MCP detector configuration. Additional surface patterning techniques can also be used to effect the desired MCP detector, such as for example, a focused ion beam (FIB) method, lithography and a laser writer. These techniques are most preferably used to pattern an external Al surface disposed on the AAO membrane **10**. As will be described in detail hereinafter, these techniques are used over Al, and AAO membrane **10** directly and Al over the AAO membrane **10**. In addition these methods can be applied directly on Al followed by anodization. Laser writer and photolithography techniques can be applied by: a) photoresist over the AAO membrane **10** or b) photoresist over Al over the AAO membrane **10**.

[0033] The nanopores **20** can be established by standard self assembly techniques, which can be quite slow and conventional ordered pore formation requires a two step anodization. Using conventional FIB and nanoimprint techniques, straight forms of the nanopores **20** develop very quickly upon anodization. Both hard and mild anodization, as well as surface patterned Al together with anodization can be used to prepare the AAO membrane **10** for the MCP detectors. FIGS. **4** and **5** show examples of hard and mild anodization prepared AAO membrane **10**.

[0034] Further examples of AAO membranes **10** fabricated by using an FIB technique are shown in FIGS. **6** and **7**. An initial pore pattern was directly formed over an Al surface followed with anodization under a high DC voltage guided by the pore-to-pore distance versus anodization potential linear correlation.

[0035] Examples of the AAO membranes **10** fabricated with a laser writer to prepare pores in the range of about 1 to 25 micrometers are shown in FIGS. **8** and **9**. The process involves making the AAO membrane **10** (about 100 microns thick) over an Al sheet, coating the AAO open nanopores **20** with a thin Al layer **15** of about 100 nm thick (see FIGS. **11**A and **11**B), using a laser writer to prepare a desired pattern, chemically etching to develop the pattern, and finally carrying out chemical etching again to generate the desired pattern in the AAO membrane **10**. The AAO membranes **10** have been micro-fabricated at sizes of about one inch diameter, and larger sizes are readily achievable using photolithography or other conventional techniques followed with chemical etching as for the FIB technique.

[0036] Additional steps can be performed to develop a bias angle in the AAO membrane **10** (see FIG. **10**) as well as a robust Al-Alumina interface. The bias angle in a conventional glass MCP detector is known to increase its efficiency. The bias angle in glass MCP is introduced through forming a cut angle during fiber glass bundle cutting. For the AAO based MCP design herein, a textured Al surface can be prepared by imprint with use of optical gratings or specially designed molds. The nanopores developed during anodization are expected to be normal to the substrate surface. Textured Al surface is expected to develop a bias angle (O) for intrinsic pores as shown in FIG. **10**. This biased angle can be controlled through a built-in angle on a conventional grating or mold in a known way. Due to the large difference in the thermal expansion coefficients between Al (23.6 ppm/° C., soft and malleable) and alumina (~6 ppm/° C., hard and rigid), the AAO membrane **10** in an Al frame should be able to tolerate stress built-up during any large temperature variation such as during thermal evaporation and resistive heating, etc. The Al-alumina interfacial area during anodization to strengthen the interface. This can be done by purposely varying the anodization area. A schematic drawing to show a suitably graded Al-alumina interface **19** is shown in FIG. **11**B.

[0037] Examples of the AAO membrane **10** fabricated with a laser writer to prepare nanopores **20** in the range of about 1 to 25 micrometers are shown in FIGS. **8** and **9**. The process involves making the AAO (about 100 microns thick) over an Al sheet, coating the AAO open nanopores **20** with a thin Al layer **15** (about 100 nm thick) shown in FIGS. **11**A and **11**B, using a laser writer to prepare the desired pattern, chemical etching to develop the pattern, and finally carrying out chemical etching again to generate the desired pattern in the AAO membrane **10**.

[0038] In the design of the AAO based MCP plates **40** for a detector, in order to enhance the radiation capture and to guide the flow of the emitted secondary electrons, it is desirable to have a funnel-shaped channel entrance **50** (see FIGS. **13**C-**13**D and **14**). The funnel-shaped entrance **50** can be fabricated with use of a photoresist layer **60** and an overetch process. As shown in FIGS. **13**A and **13**B, initial etching of the AAO membrane **10** leads to a straight channel **70**. The etching rate may be controlled with the chemical etching solution, solution concentration, etching temperature, and etching time, etc. The vertical etching propagates at a faster rate than the horizontal etching under the photoresist layer **60** due to overetching propagating at a slower rate. Through proper control of these etching processes, the funnel-shaped channel entrance **50** may be constructed (see FIGS. **13**C and **13**D). Such an example, although not yet optimized, is shown in FIG. **14**. Vertical etching leads to straight 10-micron diameter channels **70** and overetching leads to funnel-shaped rings **80** about 4-micron wide around each funnel-shaped channel entrance **50**.

[0039] For both the intrinsic nanopores **20**, as well as the open channels **50** prepared through fabrication techniques, the open channel diameter in the AAO membrane **10**, the channel-to-channel distance, the channel length/diameter (or the aspect ratio) can all be controlled through anodization and design. For the patterned open channels **50**, in order to retain the mechanical strength of the AAO membrane **10**, un-etched areas may be intentionally left. The large area MCP plates **40** of a detector, such as 8×8 in^2, can be constructed in a floor tile layout with un-etched aluminum framework.

[0040] After the AAO-based micro-channel plate components are developed as described hereinbefore, ALD is used to deposit well controlled thin films **30** to tune the electrical resistance of the AAO based components and also to enhance secondary electron emission to provide the preferred radiation sensitive channels of the MCP plates **40**. The tunable resistance thin films **30** can be comprised of mixtures of a conducting material such as zinc oxide, tin oxide, indium oxide, etc. with an electrically insulating material such as