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Peters

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[54] **VACUUM HOLDER IN EPITAXIAL GROWTH APPARATUS**

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[52] **U.S. Cl.** **118/50**; 118/52

[51] **Int. Cl.**[2] **B05C 3/02**

[58] **Field of Search** ..... 118/50, 50.1, 52, 53, 500, 118/56; 148/171, 172; 117/113–115, 101; 269/21; 23/301 S, 301 P, 274

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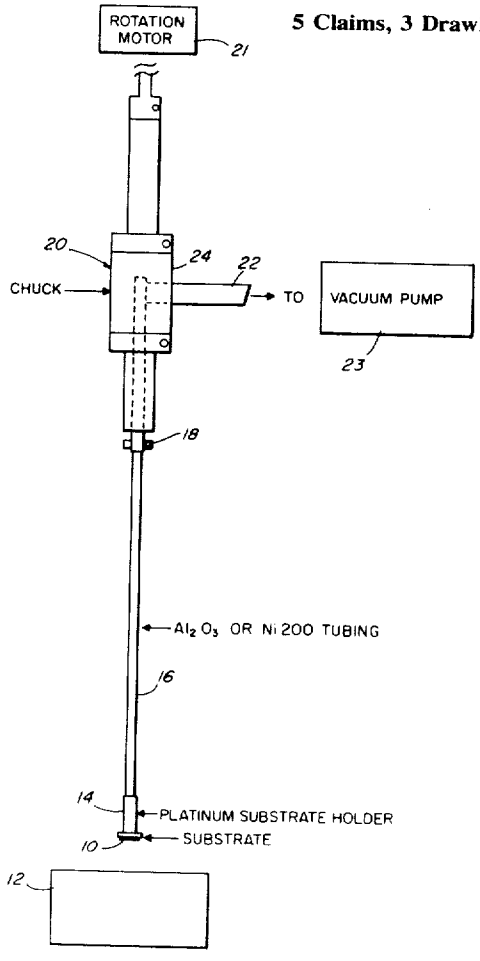
Primary Examiner—Morris Kaplan

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[57] **ABSTRACT**

An assembly for holding a wafer substrate, while it is dipped in an appropriate nutrient solution, rotates the wafer in a horizontal plane and facilitates the coating of a thin film magnetic material on only one side of the wafer. The assembly includes a holder which may have either a flat or a slightly concave, circular face whose diameter is substantially identical to that of the wafer. The holder face has openings in the central region formed through its thickness dimension. When the face is in contact with the wafer, these openings are covered permitting the pressure in the tubular central portion of the holder to be reduced by withdrawing air from it by a vertical connecting tube. The reduced pressure creates forces on the wafer which secure the wafer to the holder. The central region of the holder face may be slightly concave but the peripheral region of the holder face must be substantially flat. The holder is connected to a vertical tube whose upper end in turn is fastened to a chuck. A vacuum pump and an appropriate motor are connected to the chuck which translates the output rotation of the motor and the reduced pressure from the pump to the substrate holder.

5 Claims, 3 Drawing Figures



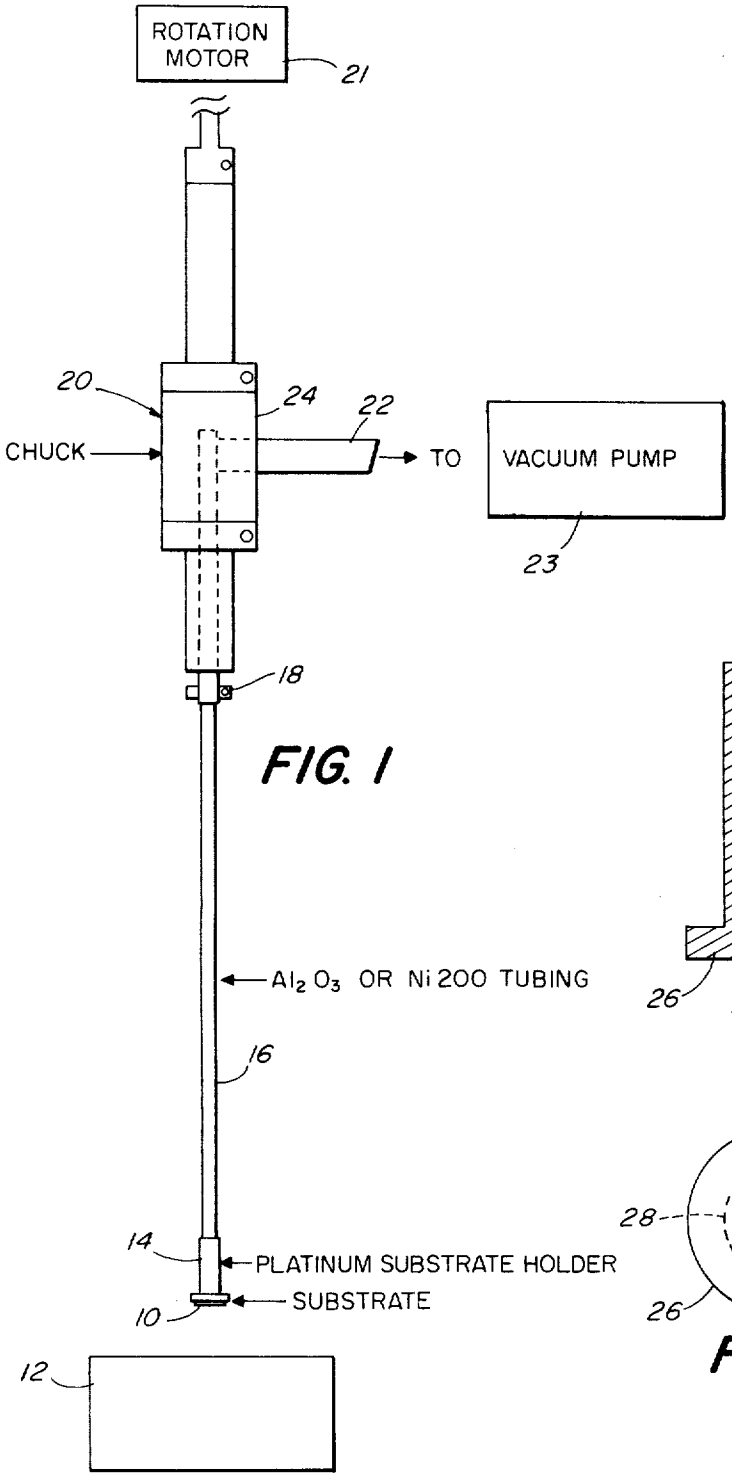


FIG. 1

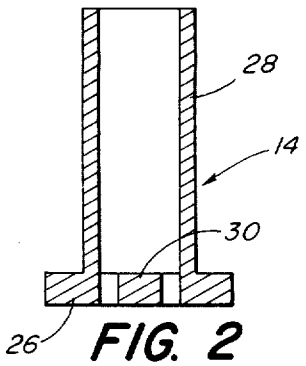


FIG. 2

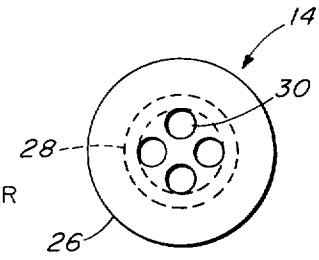


FIG. 3

VACUUM HOLDER IN EPITAXIAL GROWTH APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a substrate holder in the process of depositing a thin film magnetic material on the substrate and, more specifically, to a holder which facilitates the coating of the film on only one side of the substrate.

A technique for information storage using cylindrical domains or "bubbles" in thin plates of transparent magnetic single crystals was reported by Bobeck in Bell Sys. Tech. J. 46 1901 (1967). The application of this technology to mass memories is dependent on the availability of thin plates or films of magnetic materials which are free of defects, spatially uniform and reproducible in thickness, magnetization and material length parameter. Subsequently, it has been shown that suitable films of uniaxial magnetic garnets can be grown on non-magnetic garnet substrates (usually $Gd_3Ga_5O_{12}$) by the technique of liquid phase epitaxy; see H. Levinstein, S. Licht, R. Landoff and S. Blank, App. Phys. Letters 19, 486 (1971). The epitaxial growth process involves dipping a suitably polished single crystal wafer of a non-magnetic garnet into a super-cooled solution comprised of approximately several percent by weight of the magnetic garnet oxides dissolved in a molten flux having approximately (a 50/1 weight ratio) of PbO to B_2O_3. Since the solution is supersaturated with respect to the magnetic garnet components, a film immediately begins to deposit on the substrate crystal and growth continues until supersaturation is lost or the substrate is withdrawn from the solution.

Several methods and systems have been devised for holding the substrate wafer so that it can be conveniently inserted into, and withdrawn from, the nutrient solution. One procedure, described in S. Blank and J. Nielsen, J. Cryst, Growth 17 302 (1972), relates to suspending the substrate vertically by means of a platinum wire hook which is passed through a small hole drilled near the perimeter of the wafer. The substrate may also be held vertically in a similar method, which utilizes a platinum-rhodium clamp arrangement to grasp the wafer by its opposite edges; see W. Tolksdorf, G. Bartels, G. Espenosa, P. Holst, D. Mateika and F. Wely, J. Cryst Growth 17 322 (1972). Other procedures describe holding the substrate in a horizontal or near horizontal position by clamping it to the bottom of a closed-end platinum tube, E. Giess, J. Kuptisis, E. White, J. Cryst Growth 16 36 (1972) or fastening it in a tripod frame constructed of platinum wire.

Each of the aforementioned procedures has its attendant problems. Substrate wafers which are inserted into the nutrient solution in a vertical position are frequently subjected to the effects of an axial temperature gradient inherent in furnaces and other heating arrangements. Variations in the thickness of the deposited film arise as a consequence of this thermal gradient, and these variations can cause the cylindrical domain to become unstable and collapse or run out into a strip domain. The use of platinum or platinum-rhodium clamps or tabs to hold the substrate in position can also introduce thickness discontinuities or bubble pinning defects where they come into contact with the surface of the growing film.

SUMMARY OF THE INVENTION

The present invention relates to an apparatus for holding a substrate while it is being coated with a thin film magnetic material wherein the problems previously mentioned are overcome. More specifically, the substrate is secured to a holder by creating a partial vacuum at the interface of the holder and the substrate. The holder face to which the substrate is secured is substantially flat or slightly concave with a substantially flat peripheral region. The holder face has dimensions which are substantially the same as those of the substrate; preferably, the substrate is shaped as a wafer. The central portion of the holder face has at least one opening formed therein so that the pressure in the central tubular region may be reduced after the substrate is in contact with the holder face. The holder, which is preferably made of platinum, is adapted to be connected to a suitable tube, preferably made of alumina or nickel. A suitable device is provided for simultaneously rotating the tube and the holder and for reducing the pressure in the tube and the central tubular region of the holder. Preferably, the device is a chuck which translates the output of a motor and the reduced pressure from a vacuum pump to the substrate holder.

The method of securing the substrate to the holder during the process of coating the substrate with a thin film magnetic material is as follows: a substrate wafer is placed into contact with the face of the holder, and then the vacuum pump is started to reduce the pressure in the central tubular region of the holder, thereby creating forces which secure the wafer to the holder. The substrate is dipped into the nutrient solution, and the motor is started thereby causing the substrate to rotate horizontally in the nutrient solution. After film growth, the substrate holder and tube are allowed to return to atmospheric pressure. The substrate and film are removed from the holder by inserting a scalpel blade between them.

There are several advantages that are obtained from the use of the substrate holder of the present invention. First, the simplicity of the holder minimizes handling of the substrate wafers and thereby reduces film defects arising from scratches and dirt. Also, the need for platinum tabs and clamps and the defects and thickness variations associated with them are eliminated. Furthermore, the magnetic film is deposited on only one side of the substrate. Usually only one surface of the substrate is prepared for film deposition, and the film which grows on the unpolished face must be removed. Lastly, the holder permits the substrate to be dipped into the nutrient in a horizontal position, thereby minimizing the effects of any axial temperature gradient. The ability to rotate the substrate also helps reduce thickness variations arising from thermal effects. Interferometry indicates that films grown on substrates held in this manner exhibit thickness variations of less than one fringe of sodium light ~0.25u.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a diagram depicting the improved substrate holding system for the epitaxial growth of magnetic thin films in accordance with the present invention;

FIG. 2 is an elevational view in section of the substrate holder according to the present invention; and

FIG. 3 is a plan of the bottom of the substrate holder shown in FIG. 2.

DESCRIPTION OF PREFERRED EMBODIMENTS

In an exemplary embodiment of the present invention, FIG. 1 depicts a system utilizing a substrate holder for use in the epitaxial growth of magnetic thin film for bubble memory applications. The epitaxial growth process involves dipping a suitably polished crystal wafer **10** of a a non-magnetic garnet into a super-cooled solution, represented generally by the reference numeral **12,** comprised typically of approximately several percent by weight of magnetic garnet oxides dissolved in a molten flux having approximately (a 50/1 weight ratio) of PbO to B_2O_3. Since the solution **12** is supersaturated with respect to the magnetic garnet components, a film immediately begins to deposit on the substrate crystal **10** and growth continues until supersaturation is lost or the substrate is withdrawn from the solution. The substrate wafer **10,** which is suitably polished, is typically 0.020 to 0.025 inch thick and 0.625 to 1.0 inch in diameter. A typical film thickness is 5.0 – 7.0u.

The substrate wafer **10** is securely held in contact with a substrate holder **14** by reducing the pressure in the region between the contacting surfaces of the wafer **10** and the substrate holder **14.** The details of how this is accomplished will be described in the discussion of FIGS. 2 and 3 which follows. The holder **14** is constructed preferably of platinum so as to withstand the high temperatures and corrosive environment encountered in the epitaxial growth process. FIG. 1 shows the holder **14** as it is used in operation. The lower end of an alumina (Al_2O_3) or nickel (Ni 200) tube **16** of an appropriate size is inserted into an opening in the upper portion of the substrate holder **14.** The upper end of the tube **16** is connected by a suitable fastener **18** to a chuck **20.** The chuck **20** translates the rotating output of a motor **21** to the tube **16** and thus to the holder **14** and substrate **10.** Simultaneously, the chuck allows the air to be pumped from the substrate holder **14** and the tube **16** by a suitable vacuum pump **23.**

The operation of the chuck is as follows. The connecting tube **22** from the vacuum pump is fitted into an appropriate opening in a non-rotating housing **24** of the chuck **20.** The interfaces both of the rotating shaft from the motor and the rotating tube **16** with the chuck housing are maintained in an air tight condition. The rotation speed has an influence on the growth rate. A typical speed during the growth is 60 RPM. After growth, the flux remaining on the surface of the substrate is spun off at 1000 RPM.

Referring now to FIGS. 2 and 3, the substrate holder **14** includes a face member **26** and a connector member **28.** The connector member **28** is a tube which is adapted to fit snugly around the lower portion of the tube **16,** as shown in FIG. 1. One of the important features of the invention is the nature of the surface of the holder face **26.** The central portion of the face **26** is polished to provide either a flat or a slightly concave surface. However, if the surface is concave, the peripheral 3 mm of the face must be substantially flat. Typically, the depth of the concavity is approximately 3 interference fringes when viewed under sodium light. The central region is also formed with a plurality of small openings **30** through the thickness dimension of the holder face **26** so that the air pressure in the central tubular region may be reduced.

In operation, after the substrate wafer **10** is placed in contact with the face **26** of the substrate holder **14,** the vacuum pump is started. As the air pressure inside of the substrate holder-tubing assembly is reduced, the substrate is held securely to the face of the holder. After film growth, the substrate holder-tubing assembly is allowed to return to atmospheric pressure and the substrate and film are removed from the holder by inserting a scalpel blade between them. Interferometry measurements indicate that films grow on a substrate held in the manner herein disclosed exhibit thickness variations of less than one fringe of sodium light ~0.25u.

The typical dimensions for a substrate holder of the type shown in FIGS. 2 and 3 are as follows:

holder face diameter	5/8"
overall height	1.0"
holder face thickness	0.10"
connector member outer diameter	0.343"
connector member inner diameter	0.277" to 0.279"
diameter of each opening in holder face	0.093" to 0.095", spaced equally along a 0.188" diameter circle

In the substrate holder of the present invention, the substrate is coated on only one side regardless of whether the substrate is merely dipped into the surface of the solution or immersed below the surface. In prior holding systems of which the inventor is aware, the substrate had to be immersed below the surface to obtain the necessary film growth. However, this resulted in coating both sides of the substrate. In the present invention, the holder face is substantially flat when the substrate is only dipped into the immediate surface of the solution; when it is desirable to insert the substrate below the surface, the slightly concave holder face is preferable to insure that none of the solution leaks into the interface of the holder face and the upper surface of the substrate. The holder thus overcomes the problems of thickness variations in the film growth, particularly the trailing edges created by the holding elements, of known prior art systems of coating both sides of the substrate and of contaminating the coated surface by overcoming the need to handle the substrate while removing it from the holder. In addition, the present invention offers ease in affixing the substrate to the holder since the substrate need only be placed in contact with the face while the pump is activated.

The embodiment of the present invention is intended to be merely examplary and those skilled in the art will be able to make numerous modifications without departing from the spirit of the present invention. All such modifications are intended to be within the scope of the present invention as defined by the appended claims.

I claim:

1. An apparatus for epitaxial growth of magnetic thin film on the substrate when the substrate is dipped into a suitable nutrient solution, including:

a. a rotary platinum substrate holder having a face adapted to contact one side of the substrate, the face having a surface area adequate to enclose the entire surface of one side of the substrate so that the side of the substrate in contact with the holder

face does not contact the nutrient solution and a circular surface peripheral region of approximately 3mm which is substantially flat and bounds a central surface portion having a concavity corresponding to approximately three interference fringes when viewed under sodium light,

b. the holder further being formed with at least one opening adapted to be covered by the substrate and extending from a central region of the face through a thickness dimension of the holder,

c. tubular means connected to the holder about said opening opposed from said face,

d. means operative through said tube for reducing the pressure in the opening after the substrate is in contact with the face to secure the substrate to the holder and for rotating the holder about an axis perpendicular to the face of the holder to reduce thickness variations of the magnetic thin film which is grown on the other side of the substrate; and

e. nutrient solution containing means operatively associated with said holder to effect said growth when the substrate is dipped therein.

2. The apparatus according to claim **1** wherein the axis of rotation is vertical so that the substrate is in a horizontal plane to minimize the effects on the film thickness of vertical and horizontal temperature gradients in the nutrient solution.

3. The apparatus according to claim **1** wherein the pressure reducing and rotating means includes a vacuum pump, said tubular means being a rigid tube of extended length affixed to the holder, a motor and a chuck which is connected to the outputs of the motor and the pump and to the tube, the chuck translating the rotating output of the motor to the tube and the reduced pressure from the pump to the hollow portion of the tube and thus to the opening in the holder.

4. The apparatus according to claim **3** wherein the tube is made of alumina.

5. The apparatus according to claim **3** wherein the tube is made of nickel.

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