THIS OPINION WAS NOT WRITTEN FOR PUBLICATION

The opinion in support of the decision being entered today (1) was not written for publication in a law journal and (2) is not binding precedent of the Board.

Paper No. 41

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte ROBERT L. ANDERSON
and JOHN C. HELMER

Appeal No. 95-2413
Application 07/936,865[1]

ON BRIEF

Before HAIRSTON, KRASS, and BARRETT, Administrative Patent Judges.

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[1] Application for patent filed August 27, 1992, entitled "Sputtering Apparatus With A Rotating Magnet Array Having A Geometry For Specified Target Erosion Profile," which is a continuation of Application 07/768,098, filed September 27, 1991, now abandoned, which is a continuation of Application 07/471,898, filed January 26, 1990, now abandoned, which is a continuation-in-part of Application 07/355,713, filed May 22, 1989, now U.S. Patent 4,995,958, issued February 26, 1991.

BARRETT, Administrative Patent Judge.

DECISION ON APPEAL

This is a decision on appeal under 35 U.S.C. § 134 from the final rejection of claims 13-18, 22, and 29-62. Claims 1-12, 25, and 26 are indicated to be allowed.

We affirm-in-part.

BACKGROUND

The disclosed invention is directed to a sputtering apparatus and method having a rotatable array of magnets arranged in a geometry that provides a selected erosion profile.

Claims 34 and 36 are reproduced below.

34. A magnetron sputtering apparatus comprising:

a vacuum chamber;

a target cathode in said vacuum chamber having a smoothly continuous concave closed front surface from which material is to be sputtered and a back surface; and

a rotatable magnet means for generating a single magnetic field over said front surface, said magnet means being positioned behind said back surface.

36. A sputter source comprising:

a vacuum chamber,

a target cathode,

a closed-loop magnet behind said target cathode, said closed-loop magnet being rotatable about an axis which passes through said target cathode, said magnet having a shape which conforms to the shape of the target,

said closed-loop magnet further being shaped such that when said magnet is rotated, the total arc length of the portions of the magnet which pass beneath a point on said target cathode surface a distance R from the axis of rotation is substantially proportional to >(R)xR, for values of $R>R_0$, where >(R) is a selected function corresponding to a desired erosion profile and R_0 is a constant.

The examiner relies on the following references:

U.S. Patents

Elmgren et al. (Elmgren)	3,669,871	June 13, 1972
Wegmann et al. (Wegmann)	4,622,121	November 11, 1986
Suzuki et al. (Suzuki)	4,872,964	October 10, 1989

Japanese Laid-Open Patent Applications (Kokai)

Sato (Sato '375)	62-211375	September 17, 1987
Sato et al. (Sato '374)	63-149374	June 22, 1988
Sawada et al. (Sawada)	64-62462	March 8, 1989

Claims 13-18, 22, and 29-62 stand rejected under 35 U.S.C. § 103 as being unpatentable over either Suzuki or Sato '374 or Sato '375 in view of Elmgren, Wegmann, and Sawada.

We refer to the Office action (Paper No. 21), the Final Rejection (Paper No. 24), the Examiner's Answer (Paper No. 28) (pages referred to as "EA__"), and the Supplemental Examiner's Answer (Paper No. 33) (pages referred to as "SEA__") for a statement of the examiner's position and to the Brief (Paper No. 27) (pages referred to as "Br__") and the Reply Brief (Paper No. 29) (pages referred to as "RBr__") for a statement of the appellants' arguments thereagainst.

OPINION

Grouping of claims

Appellants divide the claims into five groups (Br3):

Group 1 - claims 36-38, 45, and 47;
Group 2 - claims 13-18, 22, 29, 30, 33-35, 42-44, and 60;
Group 3 - claims 31, 32, 46, 48-57, and 61;
Group 4 - claims 39-41;
Group 5 - claims 58, 59, and 62[2].

Obviousness

Scope and content of the prior art

Sato '375

Sato '375 describes a planar magnetron sputtering source in which a number of permanent magnets are arranged into a heart shape represented by the following formula:

r = l - a + 2a*2*/B (-B # 2 # B)

where the geometry and terms are defined in figure 3(1) and page 5 of the translation. This arrangement is said to provide uniform erosion but non-uniform film thickness (figure 3(3); translation, page 5). The formula for r is recognized as a portion of spiral having a polar equation r = b2. The first point on the curve is the smallest radius,

[2] Claim 62 depends from claim 13 and will be treated to stand or fall with claim 13 in Group 2.

l-a, which can occur at any arbitrary angle 2_0 (which can be considered the zero angle in a new coordinate system): $r = b2_0 = l-a$, at $2 = 2_0$. The greatest radius, l+a, occurs at $2 = 2_0+B$: $r = b(2_0+B) = b2_0+bB = l-a + bB = l+a$, at $2 = 2_0+B$. So $b = 2a/B$. Therefore, $r = l-a + 2a*2*/B$, for $-B \# 2 \# B$. The centers of the magnets gaps are aligned along the curve and, so, the width of the closed-loop path appears to be constant.

Sato '374

Sato '374 discloses the same heart-shaped curve based on a spiral as Sato '375, which is said to provide equal target sputtering (translation, page 7). Sato '374 provides no additional information to Sato '375.

Suzuki

Suzuki is the U.S. equivalent of European Patent Publication No. 211,412, published February 25, 1987, noted at page 2, lines 17-20, of the specification (Information Disclosure Statement, Paper No. 5). Suzuki discloses a planar magnetron sputtering source in which the magnets are arranged "to make an erosion of the target surface uniform and also to deposit the sputtering material uniformly on a substrate"

(col. 1, lines 16-18). Prior art magnetron sputtering sources, as shown in figure 4(a), used an annular magnetic field, shown as ring section 34. Suzuki recognized that erosion is a function of exposure time of the ring over the target (col. 3, lines 30-40):

> When annular ring 34 rotates around Or, eroding the target surface, a portion of the ring region in a vicinity of point B sweeps much faster than that of point A. The erosion of the target is proportional to the exposed time of the target for the plasma, and, in other words, is proportional to the quantity of the total length of an arc length divided by sweep velocity. The sweep velocity is in this case proportional to the radius of rotation and the total arc length corresponding to each point A, B, and C is shown as dashed curve length X, Y, and Z+Z' respectively in FIG. 4(a).

Suzuki discloses that "an uneven erosion is caused by a difference in the exposed time of the target for the plasma, therefore the present invention is to find a magnet arrangement, whereby the time of exposition is constant everywhere over the target surface" (col. 3, line 67 to col. 4, line 4).

Suzuki discloses a N-piece graphic method for producing uniform erosion in connection with figure 8, where N=16 in this case. An annular doughnut-shaped region 63 between inner circle 62 and outer circle 61 is an erosion area to be

uniformly eroded. The annular area is divided into N sectors 651 through 666 having an interior angle of "=2B/N by N/2 lines passing through the center. Concentric circles 671 through 677 are formed between circles 62 and 61 having equal differences in radius between two adjacent circles and thus N/2=8 circular tracks are formed. The cross points between the straight lines and circles are labeled a through p. A smooth curve 67 is drawn through these points to provide a closed-loop. It is recognized that figure 8 is merely a graphic method of construction of a spiral having a polar equation r = b2 and having a radius extending between the radius of inner circle 62 and the outer circle 61, which can be mathematically represented by the equation in Sato '375.

Suzuki states (col. 5, line 59 to col. 6, line 4):

> Assuming the curve 67 drawn in FIG. 8 corresponds to the plasma region 55 in FIG. 6(a) having a very narrow width, and the curve is rotated with an angular velocity T around Or, then after a rotation of)T, which is equal to " in this case, arc a-b moves to a'-b' and arc b-c to b'-c' respectively. Each swept area by the arcs a-b and b-c is almost proportional to radius Or-a and Or-b respectively. On the other side, a velocity which each arc sweeps the surface of the target is also proportional to the radius of rotation Or-a and Or-b respectively. As a result, any small area in the region swept by arc a-b and b-c is exposed to a plasma for the same period of time, and the erosion rate is almost the same.

The magnets in an actual design should be arranged, as far as possible, "in such a way that a center line between poles of each magnet coincides [with] the designed curve 67 of FIG. 8 . . ." (col. 6, lines 10-11).

Figure 9 provides an idealized description of figure 8 which is said to be "easier to understand" (col. 6, line 28). Each arc section of the curve 67 in figure 8 (e.g., arc a-b) is represented as a shaded arced area at constant radius in figure 9 (e.g., region 71 corresponds to the arc-shaped segment containing arc a-b in figure 8). Suzuki discloses that the idealized arrangement of figure 9 satisfies the condition:

$$'L(r)/r = '" = \text{constant}$$

We disagree with appellants' interpretation of what this means. Appellants interpret this equation to mean that L(r) is the arc length across the width of the plasma path at a radius r as shown in appellants' figure 14A. While appellants' interpretation is consistent with Suzuki's discussion of figure 4(a) (col. 3, lines 26-40), it is not consistent with Suzuki's description of the plasma having "a very narrow width" (col. 5, lines 60-61). In our opinion,

L(r) is the arc length swept by a portion of the curve 67 at a radius r, not the width of the path at radius r. That is, from figures 8 and 9, assuming the spiral curve 67 alone causes erosion (because the spiral curve 67 corresponds to the plasma region 55 and has "a very narrow width," col. 5, lines 60-61), the swept arc length L(r) increases in proportion to the radius r. Thus, arc a-b exposes the target underneath the same amount of time as arc b-c, arc c-d, etc. One of ordinary skill in the art would have recognized that the arrangement of magnets in Sato '375 was intended to perform the same function as that in Suzuki.

Wegman, Elmgren, and Sawada

These references are discussed with respect to Group 2.

Level of ordinary skill

The references are the only evidence of the knowledge and level of ordinary skill in the art. See In re Oelrich, 579 F.2d 86, 91, 198 USPQ 210, 214 (CCPA 1978) ("the PTO usually must evaluate both the scope and content of the prior art and the level of ordinary skill solely on the cold words of the literature"); In re GPAC Inc., 57 F.3d 1573, 1579, 35 USPQ2d 1116, 1121 (Fed. Cir. 1995) (the Board did not err

in adopting the approach that the level of skill in the art was best determined by the references of record). In addition, those of ordinary skill in the art must be presumed to know something about the art apart from what the references expressly disclose. In re Jacoby, 309 F.2d 513, 516, 135 USPQ 317, 319 (CCPA 1962).

Group 1 - claims 36-38, 45, and 47

Appellants' specification discusses a mathematical analysis to define a closed-loop plasma path that produces uniform erosion and which has the property that the width of the path is a constant (figure 5; specification, pages 13-16). Claim 36 does not recite a constant width path or a uniform erosion profile. Appellants state that their "contribution has been, inter alia, the teaching, based on rigorous mathematical analysis, of how to analytically design magnets to achieve desired erosion results over a large area of a target, without the need for extensive, iterative, time-consuming, trial and error techniques" (Br7). However, claim 36 is an apparatus claim, not a process claim to how to analytically design magnet arrangements. Thus, it makes no difference that the prior art may have used graphic or trial

and error techniques instead of mathematical analysis. Further, no mathematical relationships are claimed. The recitation that the "total arc length" is "substantially proportional to >(R)xR" takes exact precision out of the claim. Still further, while the function >(R) in claim 36 could be any function, claim 36 is satisfied by any single function. We keep these points in mind in addressing the obviousness rejection.

In our opinion, the subject matter of claim 36, as broadly claimed, would have been obvious over Suzuki or Sato '375 or Sato '374. We note that the limitation "the total arc length of the portions of the magnet which pass beneath a point on said target cathode surface a distance R from the axis of rotation" refers to the swept area on the target, not the arc length over the width of the plasma path. Suzuki expressly discloses that the total arc length for any portion on the magnet which passes beneath a point on the target surface a distance R from the axis of rotation (expressed as 'L(R) to be consistent with appellants' use of R instead of r) should have a constant erosion function (>(R) = constant), so 'L(R) = >(R)xR. One of ordinary skill in the magnetron

sputtering design art would have appreciated that the teaching in Suzuki is implicit in Sato '375 and Sato '374 since the graphic spiral in Suzuki is expressible as the mathematical equation in the Sato references. In addition, claim 36 is considered broad enough to read on the prior art in figure 4(a) of Suzuki, which is shown in appellants' figures 3A-3C. That is, the function in appellants' figure 3C can be expressed as a function >(R) and can be considered to be "a selected function corresponding to a desired erosion profile" (emphasis added) as recited in claim 36. For these reasons, we sustain the rejection of claims 36-38, 45, and 47 over Suzuki, Sato '375 and Sato '374.

Appellants argue that Suzuki, Sato '375, and Sato '374 do not, in fact, produce uniform erosion. First, Suzuki expressly teaches the conditions of claim 36 and Sato '375 and Sato '374 implicitly teach the conditions of claim 36, which teach one of ordinary skill in the art to do what is claimed. Suzuki expressly teaches that the way to satisfy the condition is to make the exposure time uniform over the surface to be eroded by making the arc lengths divided by the velocity a constant.

Second, in our opinion, appellants have misinterpreted the teachings of Suzuki and thus have not fairly analyzed its teachings. Appellants interpret Suzuki to mean that L(r) is the arc length across the width of the plasma path at a radius r as shown in appellants' figure 14A. We interpret Suzuki's description of the plasma having "a very narrow width" (col. 5, lines 60-61) as meaning that L(r) is the arc length swept by a portion of the curve 67 at a radius r. That is, a point on curve 67 (assumed to be a very small area because the path has a "very narrow width") at a distance r from the axis of rotation traces a narrow path of circumference of 2Br on the target and the velocity of the point is Tr, so 2Br/Tr = constant. This means that any small area in the region swept by any point on curve 67 is exposed to the plasma for the same period of time and the erosion rate is constant. This same interpretation applies to Sato '375 and Sato '374. Appellants have not analyzed "a very narrow width" plasma path having a spiral shape as shown in Suzuki, Sato '375, and Sato '374.

Third, appellants' showings with respect to Sato '375 in figures 15A and 15B are not persuasive since there appears to

be information left out. Figures 15A and 15B appear to show erosion for a spiral according to Sato '375 and appellants' mathematical analysis and do not show or discuss any width associated with path. A spiral according to Sato '375 (or Sato '374 or Suzuki) will cause uniform erosion if only the spiral curve is considered to cause the erosion.

Fourth, the claim limitation of "substantially proportional" permits some variance and appellants have not shown how this language distinguishes over the teachings of the three main references, even assuming, arguendo, they do not produce uniform erosion. Thus, for example, Suzuki's disclosure that the swept area is "almost proportional" to the radius (col. 5, line 65) and that the "erosion rate is almost the same" (col. 6, lines 3-4) is considered to disclose that the total arc length at a certain radius is "substantially proportional" to the erosion profile function times the radius.

Fifth, assuming that appellants' interpretation of Suzuki in figures 14A and 14B (which are said to show the magnetic path and erosion profile for Suzuki, specification, page 25),

is correct, figure 14B shows a uniform erosion profile for $R_0 > 2$, which meets claim 36 since R_0 is arbitrary.

Sixth, assuming that the actual erosion profile produced by Suzuki, Sato '375, and Sato '374 is not uniform, we have already noted that the actual erosion profile can still be described by a function >(R) and the total arc length must, by definition, be proportional to >(R)xR. For example, even the discontinuous function in appellants' figure 3C for an annular magnet can be described by a function >(R) and the total arc length must inherently be proportional to >(R)xR. The claim language that ">(R) is a selected function corresponding to a desired erosion profile" (emphasis added) does not distinguish the claim over the prior art where the actual erosion profile is broadly considered to be the desired erosion profile.

Appellants argue that "the actual case" magnet of FIG. 6 does not conform to the limitations of Claim 36 and is merely an interpolative design " (Br8). Appellants do not explain what limitation of claim 36 is not met by the actual magnet of Suzuki. Claim 36 is an apparatus claim and does not recite how the magnet arrangement has been designed, by interpolation or otherwise.

> Appellants argue (Br8):
>
> In contrast, the theoretical design of FIG. 9 is provided solely for heuristic purposes and is admittedly inoperative due to the multiple discontinuities in the "curve." As is well-known in the art, and as admitted by Suzuki, et al., it is not possible to create a stable plasma arrangement having discontinuities. Claim 36 of the present Application includes the requirement that the magnet be in the form of a "closed-loop," since this is a necessary condition for an actual magnet. Thus, in addition to being inoperative, the theoretical design of FIG. 9 fails to meet the claim requirement of being a closed loop.

The actual magnet of figure 6 of Suzuki is a closed-loop magnet which embodies the theoretical design in figure 9 (e.g., col. 6, lines 47-52). The magnets in an actual design are arranged, as far as possible, "in such a way that a center line between poles of each magnet coincide [with] the designed curve 67 of FIG. 8 . . ." (col. 6, lines 10-11). That is, Suzuki clearly recognizes that there must be no discontinuities and that there must be a continuous closed-loop path in an actual magnet arrangement (e.g., col. 4, lines 17-21; col. 6, lines 47-52). Appellants' arguments that figure 9 is inoperative because it shows discontinuities and does not show a closed-path are misleading and not persuasive because Suzuki clearly indicates that figure 9 is for theoretical purposes and that discontinuities

should not exist in an actual magnet, such as in figure 6. Moreover, we believe that appellants misinterpret the shaded regions in figure 9 to be the magnetic path instead of the areas swept out on the target by the arcs of the curve 67 in figure 8.

Appellants argue (Br8):

> On the other hand, the "modified" design of FIG. 6 fails to meet the total arc length limitation of Claim 36. For example, the patent admits that the actual design is such that, "Each area swept by the arcs a-b and b-c is almost proportional to radius Or-a and Or-b respectively." (Column 5, lines 64-66, emphasis added.) Thus, it is admitted that the actual magnet design only approximates the total arc length limitation and no teaching is presented which suggests how to actually achieve this limitation with a closed-loop magnet.

Suzuki expressly teaches that the total arc length (i.e., 'L(r)) at a distance r from the axis of rotation divided by the distance r should be constant, i.e., 'L(r)/r = constant. Suzuki teaches a plasma region having the disclosed spiral shape and a very narrow width will produce an erosion rate that is "almost the same" (col. 6, lines 3-4). While Suzuki admits that 'L(r)/r is not exactly constant, the disclosure of "almost the same" is considered to teach "substantially proportional" as recited in claim 36, because this term does not require exactness. Given that real magnets having finite

lengths and sizes must be used in an actual design, appellants have not shown that whatever errors are present in Suzuki are not also present in their design.

Appellants argue (Br8-9):

> Assuming, for the sake of argument, that the goal of the total arc length limitation was known at the time of the present invention, nothing in any of the prior art cited by the examiner teaches, suggests or makes obvious how one could have actually constructed a closed-loop magnet that achieved that goal. Simply telling the reader to modify the design of FIG. 9 of Suzuki, et al., using interpolation to close the gaps, would not attain the goal. As described above, minor variations in a magnet shape can result in significant variations in the resulting erosion profile. Thus, a magnet which is "almost" the right shape may produce an erosion profile which is unacceptable and which, therefore, requires considerable empirical fine-tuning effort to obtain acceptable results.

There can be no doubt that the goal of the total arc length limitation was known in view of the discussion of figure 4(a) and the condition of 'L(r)/r = constant in Suzuki. One of ordinary skill in the art was instructed to define a closed loop magnet where this condition is true at all radii. This could be done by graphical, analytical, or even trial and error techniques, since no process is recited.

Appellants argue that they were "the first to provide a clear teaching as to how to construct a mathematically defined

closed curve that truly meets the total arc lengths limitation" (Br9). No mathematical relationships or procedures are claimed and, thus, this argument is not persuasive. Furthermore, prior art figure 4(a) of Suzuki clearly teaches that the erosion profile is a function of the arc length limitations.

Appellants argue that their teachings extend well beyond attempting to achieve uniform erosion (Br9): "Applicant's invention covers [sic] also covers non-planar targets and non-uniform erosion profiles that are expressible as functions." However, claim 36 does not require non-planar targets or any special kind or number of erosion profile.

In conclusion, appellants' arguments are not persuasive of nonobviousness and the rejection of claims 36-38, 45, and 47 over Suzuki, Sato '375 and Sato '374 is sustained.

Group 2 - claims 13-18, 22, 29, 30, 33-35, 42-44, and 60[3]

The Group 2 claims require "concave" (independent claims 13 and 34), "convex" (independent claims 16 and 35),

[3] Claim 62 depends from claim 13 but has been grouped in Group 2. We consider claim 62 as part of Group 2 and to stand or fall together with claim 13.

"non-planar" (independent claim 29), or "dish-shaped" (dependent claims 42 and 60) targets with a rotatable magnet behind the target.

In the Final Rejection (Paper No. 24), the examiner inadvertently omitted the references to Elmgren, Wegmann, and Sawada showing non-planar targets, which had been applied in the previous Office action (Paper No. 21). The omitted references were applied in the Examiner's Answer and the examiner designated the rejection as a new ground of rejection. Appellants object to the new grounds of rejection; however, such procedural matters are not within the Board's jurisdiction. Moreover, the omission in the Final Rejection does appear to be an obvious error since otherwise there would be no references to show the feature of a non-planar target. We consider the rejection on the merits.

The examiner states that "[t]he secondary references show that other shapes of the targets such as concave and convex are well-known in sputtering deposition" (Paper No. 21, page 3). The examiner further states that "Wegmann in figure 2 clearly shows the concave target having rotating magnets 32 such that uniform erosion can be generated from the

target, Elmgren in figure 1 also shows that the target 29 is concave, and Japanese patent '462 [Sawada] in figures 2-3 also shows that the target 1 is either concave or convex." Appellants argue that the references are only pertinent to the claims in Group 2 (RBr3, 5). We agree with this assessment and note that it would have made for a clearer rejection if the examiner had not lumped all claims into one group. We look at each reference separately.

Wegmann

Wegmann, figure 2, discloses a sputtering device having target cathode parts 26, 27 to produce a cup-like structure. We examine only the elements associated with cathode 27. The front surface of target cathode 27 appears to be shown after some erosion has taken place and is presumed to have a "smoothly continuous concave" front surface before sputtering. A magnetic system 32 in eccentric position is provided to be rotated beneath the target cathode 27.

Claim 34 calls for a "smoothly continuous concave closed front surface." The target 27 of Wegmann, figure 2, is presumed to show the front surface after some erosion has taken place, and is presumed to have a "smoothly continuous

concave" front surface before sputtering. The magnet arrangement 32 in Wegmann is not shown. However, any of Sato '375, Sato '374, or Suzuki teaches how to provide a closed-loop magnetic path. It is noted that no special erosion profile is claimed and, thus, even a circular path would meet claim 34. The rejection of claim 34 is sustained. Appellants do not separately argue "convex" versus "concave." Therefore, the rejection of claim 35 is sustained.

Claim 29 additionally recites that the shape of segments forming a closed loop of the magnet means is "substantially conforming to a mathematical equation selected to produce a desired erosion pattern over a substantial portion of said target surface." Each of Sato '375, Sato '374, and Suzuki teaches providing a closed-loop magnetic path "conforming to a mathematical equation" for a planar target. One of ordinary skill in the art would have had sufficient knowledge and skill to apply the planar target teachings to the non-planar target of Wegmann by providing a spiral path having "a very narrow width" extending radially and axially. Every point on the target swept by this spiral would be exposed uniformly to produce a uniform "desired pattern." In addition, as a matter

of claim interpretation, "desired" is a very broad term and, in our opinion, the "desired" erosion pattern can be interpreted as the actual erosion pattern corresponding to the selected shape of the closed-loop path. We do not read into the claim any implied process-of-designing limitations that "desired" means a perfect correspondence between the intended erosion pattern and the actual erosion pattern. For these reasons, the rejection of independent claim 29 and dependent claims 30 and 33 is sustained.

Claim 13 recites that the magnetic means has a "centerline . . . configured to conform to a mathematical equation such that a substantial portion of said target cathode undergoes erosion in a preselected pattern, said preselected erosion pattern being expressible as a mathematical equation." As discussed with respect to claim 29, one of ordinary skill in the art would have had sufficient knowledge and skill to apply the planar target teachings of the main references to the non-planar target of Wegmann. Every point on the target swept by this spiral would be exposed uniformly to produce a uniform "preselected pattern." In addition, as a matter of claim interpretation,

"preselected" is a very broad term and, in our opinion, the "preselected" erosion pattern can be interpreted as the actual erosion pattern corresponding to the selected shape of the closed-loop path. We do not read into the claim any implied process-of-designing limitations that "preselected" means a perfect correspondence between the intended and the actual erosion pattern. Any continuous erosion pattern is considered to be "expressible as a mathematical equation." For these reasons, the rejection of independent claim 13 and dependent claims 14, 15, and 62 is sustained. Appellants do not separately argue "convex" versus "concave." Therefore, the rejection of independent claim 16 and dependent claims 17, 18, and 22 is likewise sustained.

Claims 42-44 and 60 are dependent claims reciting non-planar targets. It would have been obvious to apply the planar teachings of Suzuki, Sato '375, or Sato '374 to a non-planar target as taught by Wegmann for the reasons discussed in connection with claims 13 and 29, supra. Since these claims depend on independent claims whose rejections have been sustained, the rejection of claims 42-44 and 60 is sustained.

Appellants argue (Br9): "There is nothing in the teachings of this patent [Sato '374] which suggests or makes obvious how to adapt the formula to extend beyond planar target designs. Likewise, the teachings of the Suzuki, et al., patent are limited to planar targets and it would not have been obvious how [to] extend the teachings of the patent to non-planar targets." Obviousness is determined through the eyes of one of ordinary skill in the art, not just from the express teachings of the references. One skilled in the art would have known that Suzuki's teaching that the time of exposure of the target should be constant would apply equally to a non-planar target and would have been motivated to apply such teaching to Wegmann's teaching of non-planar targets. As discussed, supra, the claims are not interpreted to require a perfect correspondence between the intended erosion pattern and the actual erosion pattern.

Appellants argue that Wegmann "does not teach the importance of obtaining any particular erosion profile of either of the sputter targets, or how the erosion profiles are related to achieving the primary goals of film uniformity and

step-coverage" (RBr9). The primary references, not Wegmann, are relied on to teach providing an erosion profile.

Sawada

Appellants argue that Sawada is directed to preventing warping of the target (RBr6). We agree. Figures 2 and 3 show a target in which warping has occurred. Sawada is not directed to a non-planar target. Therefore, Sawada cannot suggest a non-planar target. Accordingly, the rejection of claims 13-18, 22, 29, 30, 33-35, 42-44, and 60 over either Suzuki or Sato '374 or Sato '375 in view of Sawada is reversed.

Elmgren

Appellants argue that Elmgren discloses a diode sputtering apparatus having a concave target and that in diode sputtering no magnets are used (RBr6-7). Appellants argue that the focussing effect in Elmgren is quite dubious (RBr6-7). The examiner has not pointed to any motivation, either in the references or in the knowledge of one of ordinary skill in the art, for combining the rotating magnet magnetron sputtering device of the primary references with the concave target of Elmgren. It appears that the motivation for

using a concave target as taught by Elmgren with a moving magnet magnetron sputtering device comes from appellants' disclosure. Accordingly, the rejection of claims 13-18, 22, 29, 30, 33-35, 42-44, and 60 over either Suzuki or Sato '374 or Sato '375 in view of Elmgren is reversed.

Group 3 - claims 31, 32, 46, 48-57, and 61

The Group 3 claims are all directed to rotating magnets that include a plurality of individual magnets that are positioned between spaced apart "keepers" or pole pieces. Claims 46 and 48 recite "closed-loop magnetic pole pieces" and claim 61 recites "bending two flexible pole pieces into calculated closed-loop shapes." Claim 31 recites "spaced-apart keepers for holding said magnet array in position, said keepers substantially conforming to the shape of said centerline and offset therefrom," which implicitly requires that the keepers be in a "closed-loop" to perform the function of holding the magnet array in position.

The examiner states that "Suzuki in column 1, line [sic] 45-50 shows that the inner and outer magnets are kept and held by magnetic yoke 3, it is therefore considered that while the magnets keeper are not shown for the purpose of simplicity,

however, without the keepers or pole pieces, the heart shape of the erosion profile would be disturbed and changed" (EA6).

Appellants argue that "[n]one of the prior art relied upon by the Examiner shows, suggests or makes obvious the use of keepers to hold a plurality of individual magnets in a rotating magnet array" (Br10). Appellants further argue that Suzuki "does not show the use of a plurality of magnets in an array positioned between keepers" (RBr13).

We agree that the applied prior art of Suzuki, Sato '374, and Sato '375 does not show keepers, as claimed. The examiner's conclusion that there must be keepers meeting the claim limitations that are not shown for reasons of simplicity is without any factual basis in the references. Therefore, the rejection of claims 31, 32, 46, 48-57, and 61 is reversed.

Group 4 - claims 39-41

The Group 4 claims are directed to magnet arrangements to achieve specific non-uniform erosion patterns, i.e., a "trigonometric function" (claim 39), a "step function" (claim 40), and a "non-constant linear function" (claim 41).

The examiner states that "[w]ith respect to the non-uniform erosion, figure 1 of the Japanese patent '375 and

figures 5-6 of Japanese patent [']374 show that other erosion [sic, magnet] shapes would generate non-uniform erosion because only the heart shape is taught to create uniform erosion" (EA6). This appears to be the first time this argument has been raised or that the claims have been addressed.

Appellants argue that the claims do not read on any non-uniform erosion profile that happens to result and "the Group 4 claims are all directed to specific shapes and all require that the shapes be expressible in the form of a mathematical function denoted as >(r)" (RBr13-14). We agree that claims 39-41 require specific erosion profiles that are not disclosed or suggested in the references. Therefore, the rejection of claims 39-41 is reversed.

Group 5 - claims 58, 59, and 62

Claim 58 is representative of the claims in Group 5. Claim 62 depends from claim 13 and, therefore, is considered to stand or fall with claim 13 in Group 2.

Suzuki discloses selecting the erosion to be uniform or constant (e.g., col. 3, line 53; col. 6, line 42), which meets the step of "selecting a desired erosion profile . . .

expressible as a mathematical equation." As evidenced by Sato '375, the curve 67 in Suzuki can be represented as a mathematical equation r = l - a + 2a*2*/B and the magnet segments are arranged such that a center line between the poles of the magnets coincides with the designed curve 67 to form a closed-loop path (col. 6, lines 8-14). Therefore, in our opinion, the magnet arrangement of Suzuki satisfies the claim 58 limitation of "said rotating magnet comprising joined segments having a shape conforming to a mathematical equation calculated to produce said desired erosion profile." It is noted that "calculated" is not recited as a method step. The term "calculated" can be interpreted as "worked out by mathematical calculation," Webster's New Collegiate Dictionary (G.&C. Merriam Co., 1977), or, more broadly, as "planned or contrived to accomplish a purpose," id. Claims are interpreted broadly during prosecution. Therefore, the "shape conforming to a mathematical equation" needs only to be planned "to produce said desired erosion profile," which is met by Suzuki. For these reasons, we sustain the rejection of claims 58 and 59.

Appellants argue that Sato '375 and '374 do not produce uniform target erosion as discussed in connection with appellants' figure 15 (Br12). The language of claim 58 does not define how precisely the desired erosion profile must match the actual erosion profile.

CONCLUSION

The rejection of claims 13-18, 22, 29, 30, 33-38, 42-45, 47, 58-60, and 62 is sustained.

The rejection of claims 31, 32, 39-41, 46, 48-57, and 61 is reversed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 CFR § 1.136(a).

AFFIRMED-IN-PART

KENNETH W. HAIRSTON Administrative Patent Judge	)
ERROL A. KRASS Administrative Patent Judge	) BOARD OF PATENT APPEALS AND INTERFERENCES
LEE E. BARRETT Administrative Patent Judge	)

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