thick in the center and thin on the periphery will occur in the end.

In view of the above-described two types of defects in the prior art, the question challenging those skilled in the art is: how to provide a magnetron capable of increasing the uniformity of the thickness of the thin film.

Summary of the Invention

Based on this, it is necessary to provide a uniformly sputtering magnetron and a magnetron sputtering device including the same.

A magnetron of the present invention comprises an inner magnetic pole and an outer magnetic pole with opposite polarities, wherein the inner magnetic pole and the outer magnetic pole are each formed of a plurality of spiral lines, the spiral lines of the inner magnetic pole are surrounded by those of the outer magnetic pole, and a gap is provided between the inner magnetic pole and the outer magnetic pole; and the gap has different widths at different positions from a spiral center to a spiral periphery; and

the spiral lines of the outer magnetic pole and the spiral lines of the inner magnetic pole satisfy the following polar coordinate equation:

$$r = a\times\theta^{n} + b\times(\cos\theta)^{m} + c\times(\tan\theta)^{k} + d$$

where r and θare polar coordinates; a, b, c, d are constants; $0\leq n\leq 2$, $0\leq m\leq 2$, $c = 0$ or $k = 0$.

Optionally, the width of the gap gradually decreases or gradually increases from the spiral center to the spiral periphery.

Optionally, the width of the gap ranges from 10mm to 60mm.

Optionally, quantities of the spiral lines forming the inner magnetic pole and the outer magnetic pole are both three.

Optionally, the width of the gap gradually decreases ~~from the spiral center to a spiral intermediate part~~ from a spiral intermediate part to the spiral center, and the width of the gap gradually decreases from the spiral intermediate part to the spiral periphery as well; or the width of the gap gradually increases ~~from the spiral center to a spiral intermediate part~~ from a spiral intermediate part to the spiral center, and the width of the gap gradually increases from the spiral intermediate part to the spiral periphery as well.

Optionally, polar coordinate equations for the three spiral lines of the inner magnetic pole are, respectively:

$r = 4.875\times\theta^{1.701} + 1.46\times(\cos\theta)^{1.244} - 26.72$, where $1.5\pi\leq\theta\leq 2.6\pi$;

$r = 8.31\times\theta^{1.235} + 10.84\times(\cos\theta)^{1.362} + 39.02$, where $1.72\pi\leq\theta\leq 3.14\pi$;

CLAIMS:

1. A magnetron, comprising an inner magnetic pole and an outer magnetic pole with opposite polarities, wherein the inner magnetic pole and the outer magnetic pole are each formed of a plurality of spiral lines, the spiral lines of the inner magnetic pole are surrounded by the spiral lines of the outer magnetic pole, and a gap is provided between the inner magnetic pole and the outer magnetic pole; and the gap has different widths at different positions from a spiral center to a spiral periphery; and

the spiral lines of the outer magnetic pole and the spiral lines of the inner magnetic pole satisfy the following polar coordinate equation:

$$r = a \times \theta^n + b \times (\cos\theta)^m + c \times (\tan\theta)^k + d$$

where r and θ are polar coordinates; a, b, c, d are constants; $0 \leqslant n \leqslant 2$, $0 \leqslant m \leqslant 2$, $c = 0$ or $k = 0$.

2. The magnetron according to claim 1, wherein the width of the gap gradually decreases or gradually increases from the spiral center to the spiral periphery.

3. The magnetron according to claim 1, wherein the width of the gap ranges from 10mm to 60mm.

4. The magnetron according to any one of claims 1 to 3, wherein quantities of the spiral lines forming the inner magnetic pole and the outer magnetic pole are both three.

5.The magnetron according to claim 4, wherein the width of the gap gradually decreases from the spiral center to a spiral intermediate part, and the width of the gap gradually decreases from the spiral intermediate part to the spiral periphery as well; or

the width of the gap gradually increases from the spiral center to a spiral intermediate part, and the width of the gap gradually increases from the spiral intermediate part to the spiral periphery as well.

6. The magnetron according to claim 4, wherein polar coordinate equations for the three spiral lines of the inner magnetic pole are, respectively:

$r = 4.875 \times \theta^{1.701} + 1.46 \times (\cos\theta)^{1.244} - 26.72$, where $1.5\pi \leqslant \theta \leqslant 2.6\pi$;

$r = 8.31 \times \theta^{1.235} + 10.84 \times (\cos\theta)^{1.362} + 39.02$, where $1.72\pi \leqslant \theta \leqslant 3.14\pi$;

$r = 4.64 \times \theta^{2} + 35.84 \times (\cos\theta)^{1.695} - 48.52$, where $1.1\pi \leqslant \theta \leqslant 1.72\pi$; and

polar coordinate equations for the three spiral lines of the outer magnetic pole are:

$r = 4.75 \times \theta^{1.92} + 1.25 \times (\cos\theta)^{1.56} + 32.49$, where $0.25 \leqslant \theta \leqslant 2\pi$;

$r = 17.54 \times \theta^{0.78} + 5.45 \times (\cos\theta)^{1.12} + 179.42$, where $0 \leqslant \theta \leqslant 1.15\pi$;

$r = 6.42 \times \theta^{1.98} + 1.88 \times (\cos\theta)^{1.95} + 45.41$, where $0.3 \leqslant \theta \leqslant 1.14\pi$.

7. The magnetron according to any one of claims 1 to 3, wherein the magnetron is applicable to a standard chamber; and

in the standard chamber, a distance from a target material to a substrate is smaller than 80mm.

8. The magnetron according to claim 4, wherein among the three spiral lines of the outer magnetic pole, two spiral lines correspond to a position at which a periphery of the gap is located, and ends of the two spiral lines are connected end-to-end by an arc line.

9. The magnetron according to claim 8, wherein the arc line satisfies the following polar coordinate equation:

$\rho^{2} + 303 \times \rho \times \cos\theta + 140 \times \rho \times \sin\theta + 25872 = 0$,

where ρ and θ are polar coordinates; $1.2\pi \leqslant \theta \leqslant 2.2\pi$.

10. A magnetron sputtering device, comprising a magnetron chamber, a vacuum process chamber, a target material, a substrate and a tray, and further comprising the magnetron according to any one of claims 1 to 9; wherein

the tray is provided in the vacuum process chamber, an upper surface of the tray used as a bearing surface for bearing the substrate;

the magnetron is provided in the magnetron chamber;

the target material is provided between the magnetron chamber and the vacuum process chamber, a back surface of the target material facing the magnetron chamber.

11. The magnetron sputtering device according to claim 10, wherein a distance from the target material to the substrate is 50-80mm, when the magnetron sputtering device is

used for deposition of metal hard mask TiN.

12. The magnetron sputtering device according to claim 10, wherein a distance from the target material to the substrate is 30-90mm, when the magnetron sputtering device is used for deposition of other nitride than TiN or metal.

13. The magnetron sputtering device according to claim 10, wherein the gap passes through a center and a periphery of the target material, during a scanning performed on the target material by the magnetron.

CLAIMS:

1. A magnetron, comprising an inner magnetic pole and an outer magnetic pole with opposite polarities, wherein the inner magnetic pole and the outer magnetic pole are each formed of a plurality of spiral lines, the spiral lines of the inner magnetic pole are surrounded by the spiral lines of the outer magnetic pole, and a gap is provided between the inner magnetic pole and the outer magnetic pole; and the gap has different widths at different positions from a spiral center to a spiral periphery; and

the spiral lines of the outer magnetic pole and the spiral lines of the inner magnetic pole satisfy the following polar coordinate equation:

$$r = a \times \theta^n + b \times (\cos\theta)^m + c \times (\tan\theta)^k + d$$

where r and θ are polar coordinates; a, b, c, d are constants; $0 \leqslant n \leqslant 2$, $0 \leqslant m \leqslant 2$, $c = 0$ or $k = 0$.

2. The magnetron according to claim 1, wherein the width of the gap gradually decreases or gradually increases from the spiral center to the spiral periphery.

3. The magnetron according to claim 1, wherein the width of the gap gradually decreases from a spiral intermediate part to the spiral center, and the width of the gap gradually decreases from the spiral intermediate part to the spiral periphery as well; or

the width of the gap gradually increases from a spiral intermediate part to the spiral center, and the width of the gap gradually increases from the spiral intermediate part to the spiral periphery as well.

4. The magnetron according to claim 1, wherein the width of the gap ranges from 10mm to 60mm.

5. The magnetron according to any one of claims 1 to 4, wherein quantities of the spiral lines forming the inner magnetic pole and the outer magnetic pole are both three.

6. The magnetron according to claim 5, wherein polar coordinate equations for the three spiral lines of the inner magnetic pole are, respectively:

$r = 4.875 \times \theta^{1.701} + 1.46 \times (\cos\theta)^{1.244} - 26.72$, where $1.5\pi \leqslant \theta \leqslant 2.6\pi$;

$r = 8.31 \times \theta^{1.235} + 10.84 \times (\cos\theta)^{1.362} + 39.02$, where $1.72\pi \leqslant \theta \leqslant 3.14\pi$;

$r = 4.64 \times \theta^{2} + 35.84 \times (\cos\theta)^{1.695} - 48.52$, where $1.1\pi \leqslant \theta \leqslant 1.72\pi$; and

polar coordinate equations for the three spiral lines of the outer magnetic pole are:

$r = 4.75 \times \theta^{1.92} + 1.25 \times (\cos\theta)^{1.56} + 32.49$, where $0.25 \leqslant \theta \leqslant 2\pi$;

$r = 17.54 \times \theta^{0.78} + 5.45 \times (\cos\theta)^{1.12} + 179.42$, where $0 \leqslant \theta \leqslant 1.15\pi$;

$r = 6.42 \times \theta^{1.98} + 1.88 \times (\cos\theta)^{1.95} + 45.41$, where $0.3 \leqslant \theta \leqslant 1.14\pi$.

7. The magnetron according to any one of claims 1 to 4, wherein the magnetron is applicable to a standard chamber; and

in the standard chamber, a distance from a target material to a substrate is smaller than 80mm.

8. The magnetron according to claim 5, wherein among the three spiral lines of the outer magnetic pole, two spiral lines correspond to a position at which a periphery of the gap is located, and ends of the two spiral lines are connected end-to-end by an arc line.

9. The magnetron according to claim 8, wherein the arc line satisfies the following polar coordinate equation:

$\rho^{2} + 303 \times \rho \times \cos\theta + 140 \times \rho \times \sin\theta + 25872 = 0$,

where ρ and θ are polar coordinates; $1.2\pi \leqslant \theta \leqslant 2.2\pi$.

10. A magnetron sputtering device, comprising a magnetron chamber, a vacuum process chamber, a target material, a substrate and a tray, and further comprising the magnetron according to any one of claims 1 to 9; wherein

the tray is provided in the vacuum process chamber, an upper surface of the tray used as a bearing surface for bearing the substrate;

the magnetron is provided in the magnetron chamber;

the target material is provided between the magnetron chamber and the vacuum process chamber, a back surface of the target material facing the magnetron chamber.

11. The magnetron sputtering device according to claim 10, wherein a distance from the target material to the substrate is 50-80mm, when the magnetron sputtering device is

used for deposition of metal hard mask TiN.

12. The magnetron sputtering device according to claim 10, wherein a distance from the target material to the substrate is 30-90mm, when the magnetron sputtering device is used for deposition of other nitride than TiN or metal.

13. The magnetron sputtering device according to claim 10, wherein the gap passes through a center and a periphery of the target material, during a scanning performed on the target material by the magnetron.