

DESCRIPTION

WIRE SAW APPARATUS, AND CUT-MACHINING METHOD

5 TECHNICAL FIELD

[0001] The present disclosure relates to wire saw apparatuses and cut-machining methods for materials to be machined (hereinafter referred to as workpiece) such as silicon ingots.

10 BACKGROUND ART

[0002] Using a wire saw apparatus known in the art is a typical technique to slice a workpiece, such as a silicon ingot, into thin wafers. Such a wire saw apparatus slices the workpiece simultaneously at several spots on the workpiece by pressing the workpiece against a cutting wire which is spirally wound around multiple wire guides,
15 while running the cutting wire.

[0003] Moreover, for example, a wire saw apparatus disclosed in PATENT DOCUMENT 1 carries out cut-machining on a workpiece by causing a wire guide (i.e., a workpiece roller) to run a cutting wire, and, simultaneously, causing the wire guide as well as the cutting wire to swing. Compared with a case where the cutting wire is not
20 swung, this technique shorten the length of contact between the workpiece and the cutting wire, which can increase a cutting force to accelerate the cutting speed, and improve efficiency in ejecting swarf to achieve higher machining accuracy.

CITATION LIST

25 PATENT DOCUMENT

[0004] PATENT DOCUMENT 1: Japanese Patent Application No. H01-171753

CLAIMS

1. A wire saw apparatus which executes cut-machining on a material to be machined, by pressing the material against a cutting wire spirally wound around a plurality of wire guides while running the cutting wire and simultaneously swinging the plurality of the wire guides as well as the cutting wire, the wire saw apparatus comprising

a controller configured to control a position of a holder for holding the material, the position being controlled depending on a swing angle of the cutting wire so that machined portion of the material is shaped into an arc, wherein

$$A \geq L / (2 \times \sin \theta)$$

where θ is the swing angle of the cutting wire, L is a maximum cut length of the material, and A is a radius of the arc.

2. The wire saw apparatus of claim 1, wherein the cutting wire swings while making a point contact with the material of which machined portion is shaped into the arc.

~~3. The wire saw apparatus of claim 1 or 2, wherein~~

~~$$A \geq L / (2 \times \sin \theta)$$~~

~~where θ is the swing angle of the cutting wire, L is a maximum cut length of the material, and A is a radius of the arc.~~

~~4.~~ The wire saw apparatus of ~~any one of~~ claims 1 ~~or 2~~ to ~~3~~, wherein

the arc has a radius which gradually decreases as the cut-machining on the material progresses.

~~5.~~ The wire saw apparatus of any one of claims 1 to ~~4~~, wherein

the cutting wire is not swung immediately after a start of the cut-machining on the material.

65. The wire saw apparatus of any one of claims 1 to 54, wherein
$$P = P_0 - ((r + A) / \cos \theta) - (r + A),$$

where θ is the swing angle of the cutting wire, r is a radius of each wire guide, A
5 is a radius of the arc, P_0 is a reference position of the holder, and P is a control position
of the holder.

76. The wire saw apparatus of any one of claims 1 to 65, wherein
the cutting wire is a fixed abrasive wire.

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87. A cut-machining method for executing cut-machining on a material to be
machined, by pressing the material against a cutting wire spirally wound around a
plurality of wire guides while running the cutting wire and simultaneously swinging the
plurality of the wire guides as well as the cutting wire, the cut-machining method
15 comprising

controlling a position of a holder for holding the material, the position being
controlled depending on a swing angle of the cutting wire so that machined portion of
the material is shaped into an arc, wherein

$$A \geq L / (2 \times \sin \theta),$$

20 where θ is the swing angle of the cutting wire, L is a maximum cut length of the
material, and A is a radius of the arc.

98. The cut-machining method of claim 87, wherein
the cutting wire swings while making a point contact with the material of which
25 machined portion is shaped into the arc.

~~10. The cut-machining method of claim 8 or 9, wherein~~
~~$$A \geq L / (2 \times \sin \theta),$$~~
~~where θ is the swing angle of the cutting wire, L is a maximum cut length of the~~
30 ~~material, and A is a radius of the arc.~~

419. The cut-machining method of ~~any one of claims 7 or 8 to 10~~, wherein the arc has a radius which gradually decreases as the cut-machining on the material progresses.

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4210. The cut-machining method of any one of claims 87 to 419, wherein the cutting wire is not swung immediately after the start of the cut-machining on the material.

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4311. The cut-machining method of any one of claims 87 to 4210, wherein $P = P0 - ((r + A) / \cos\theta) - (r + A)$, where θ is the swing angle of the cutting wire, r is a radius of each wire guide, A is a radius of the arc, $P0$ is a reference position of the holder, and P is a control position of the holder.

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4412. The cut-machining method of any one of claims 87 to 4311, wherein the cutting wire is a fixed abrasive wire.