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**Tsironis**

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(54) **WAFER PROBE INTEGRATION WITH LOAD PULL TUNER**

(71) Applicant: **Christos Tsironis**, Kirkland (CA)

(72) Inventor: **Christos Tsironis**, Kirkland (CA)

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***G01R 31/28*** (2006.01)
***G01R 1/067*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***G01R 1/06788*** (2013.01); ***G01R 1/06794*** (2013.01); ***G01R 31/2891*** (2013.01)

(58) **Field of Classification Search**
CPC ..... G01R 1/06788; G01R 1/06794; G01R 31/2891
See application file for complete search history.

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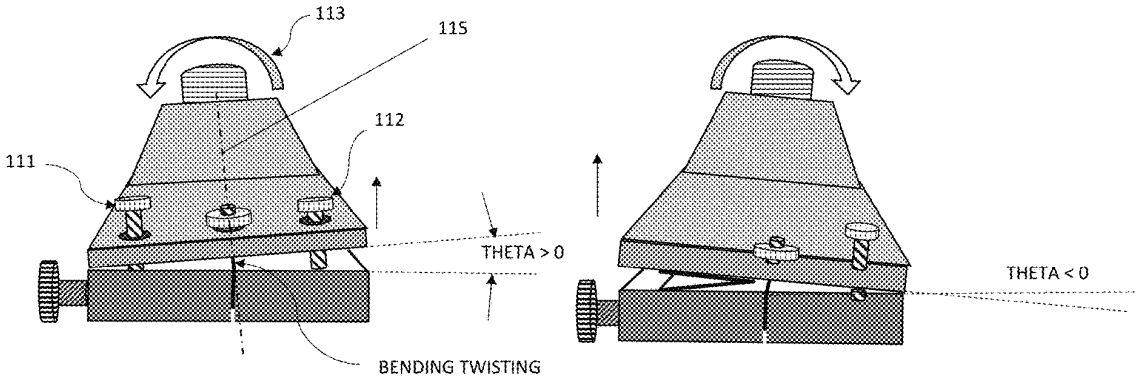
*Primary Examiner* — Paresh Patel

(57) **ABSTRACT**

Integrating a bracket with planarity adjustment holding a wafer probe securely, with a low-profile impedance tuner that is mounted on a 3-axis tuner positioner under an angle matching the angle of the wafer probe. The low-profile tuner has its tuning probe operating as close as physically possible within the distance of an RF adapter from the wafer-probe and is connected directly with the wafer-probe. This integration offers the maximum possible tuning range, while simultaneously offering planarity (THETA) control. It also eliminates the need for an extension RF cable between the instrument (tuner) and the wafer-probe, including a set of two coaxial adapters.

**5 Claims, 19 Drawing Sheets**



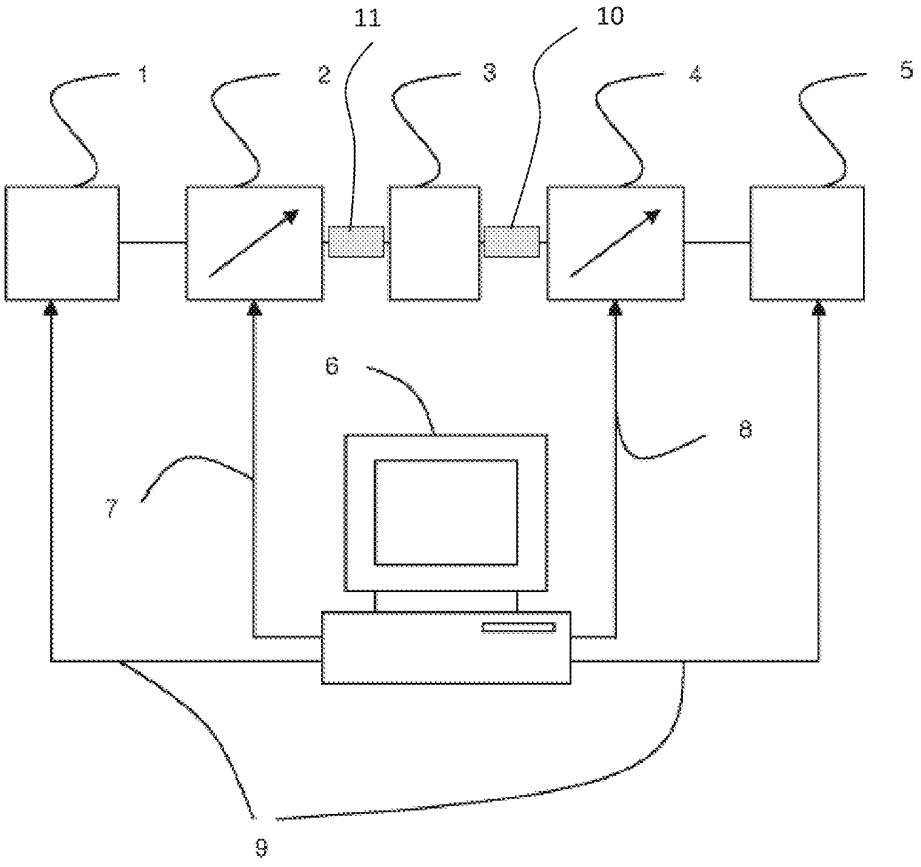



FIG. 1: Prior art

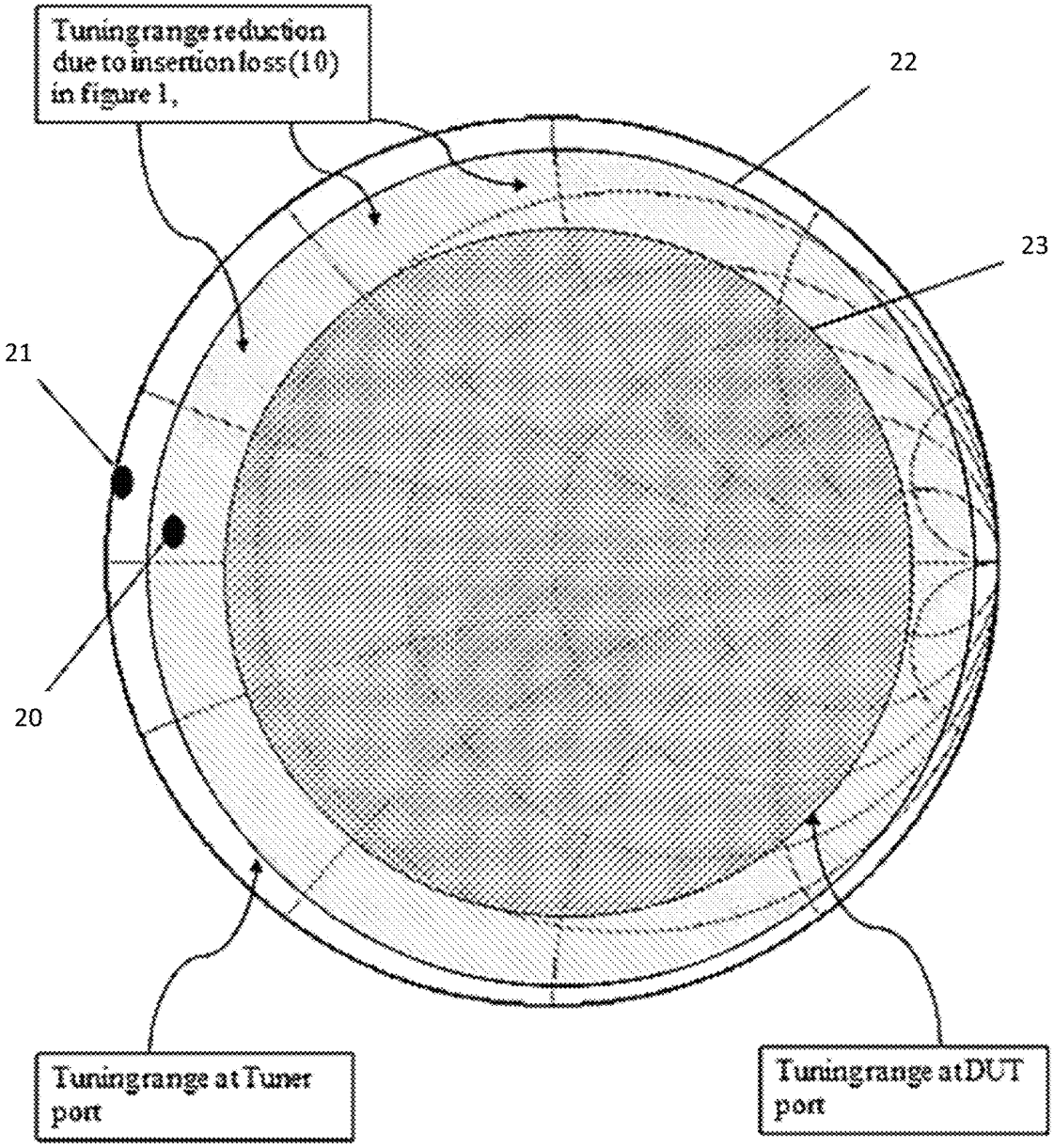



FIG. 2: Prior art

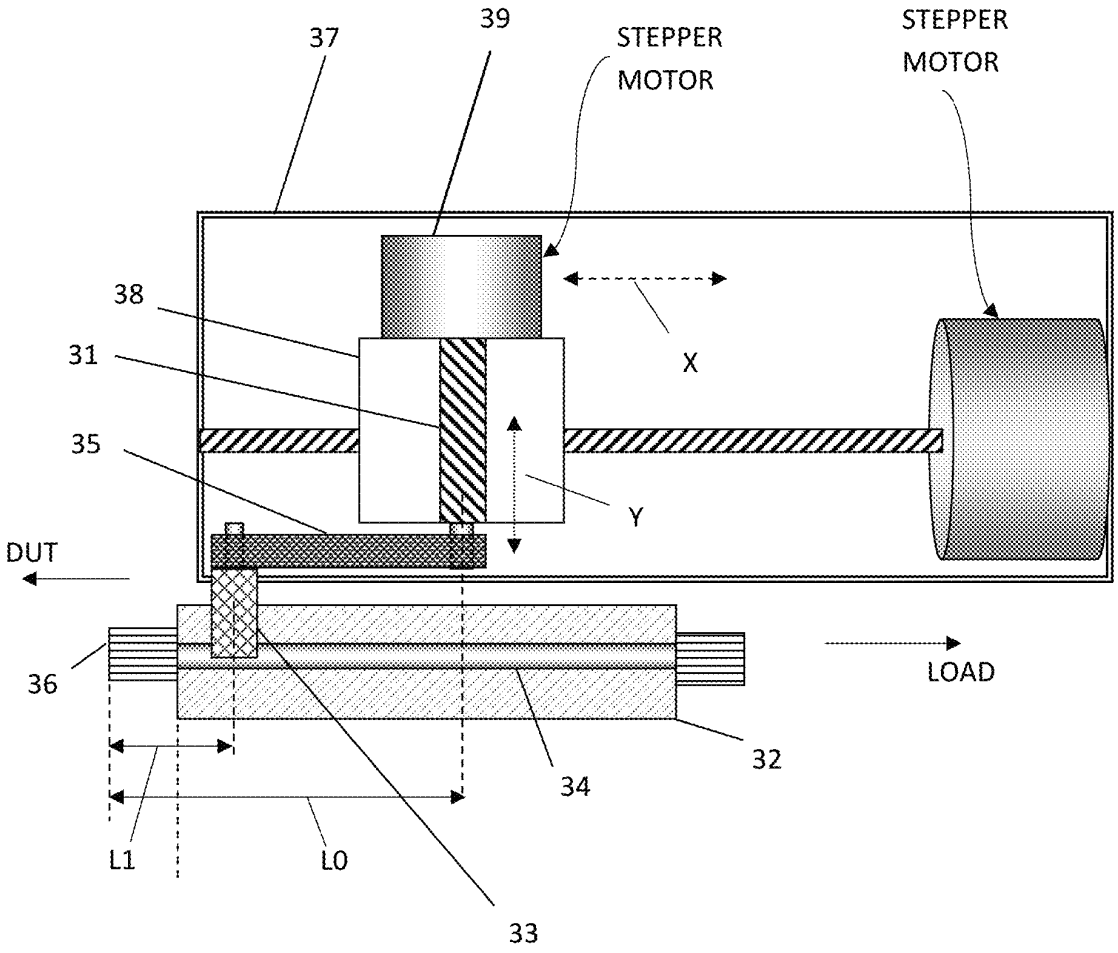



FIG. 3: Prior art

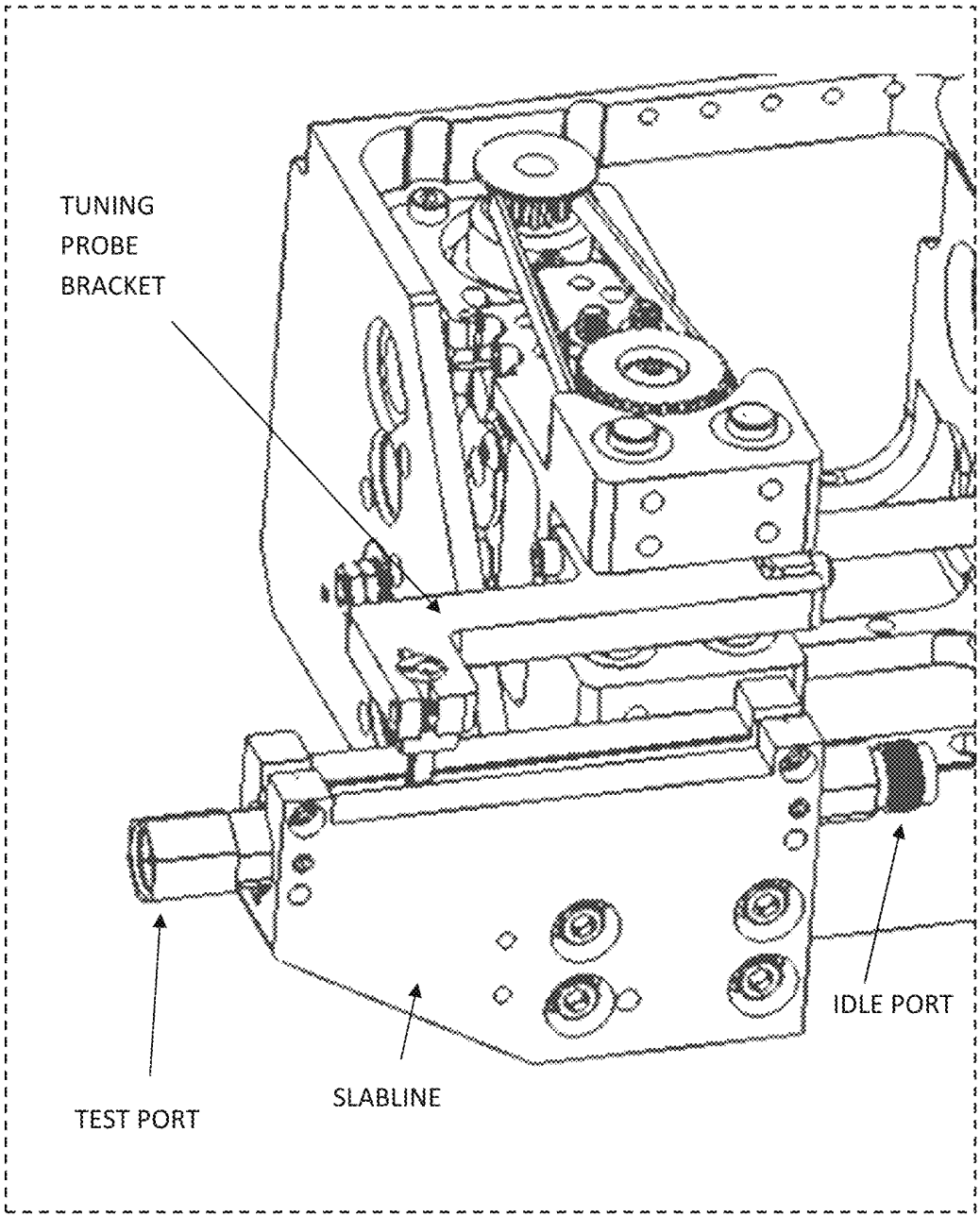



FIG. 4: Prior art

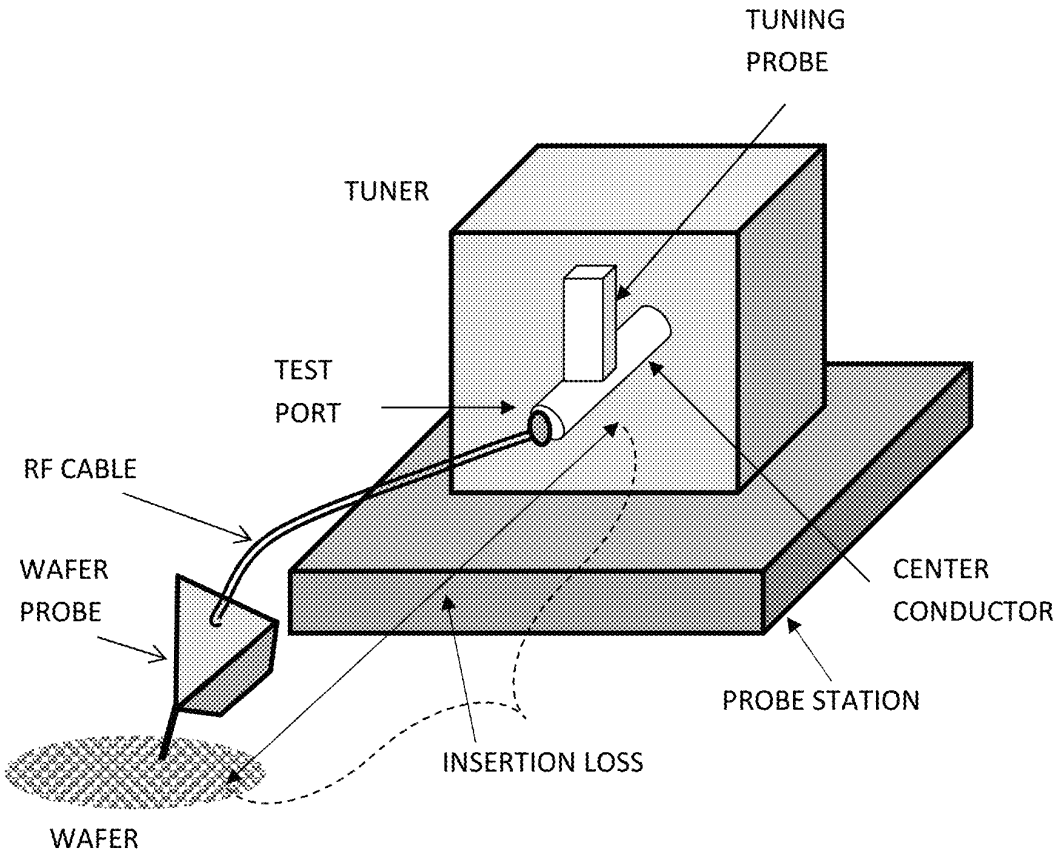



FIG. 5: Prior art

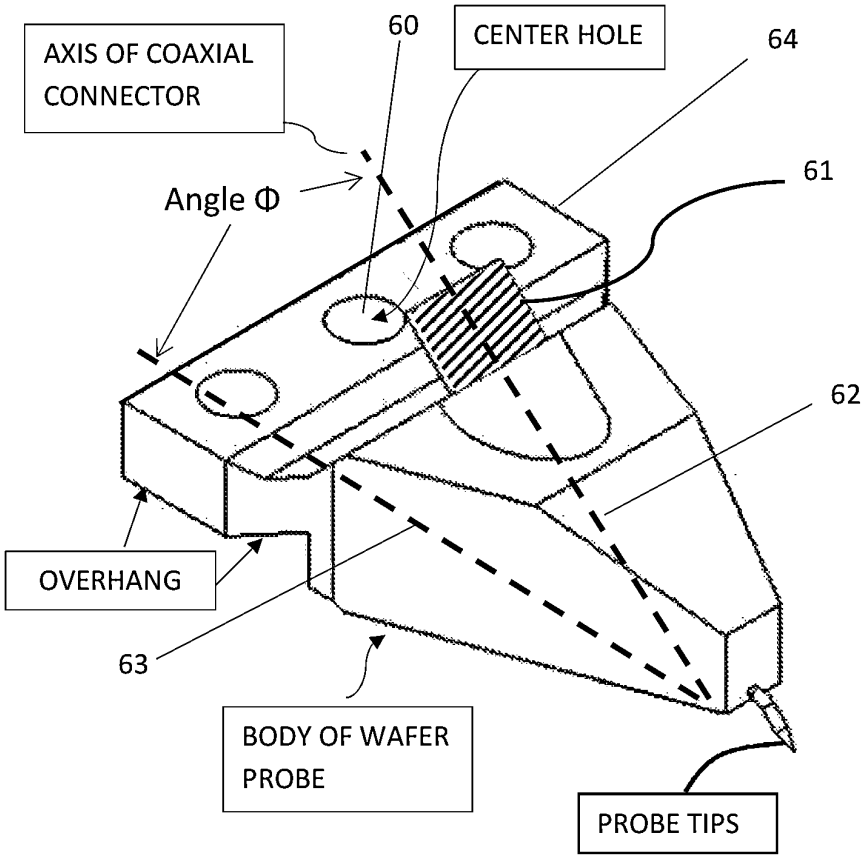



FIG. 6: Prior art

FIG.7A: Prior art

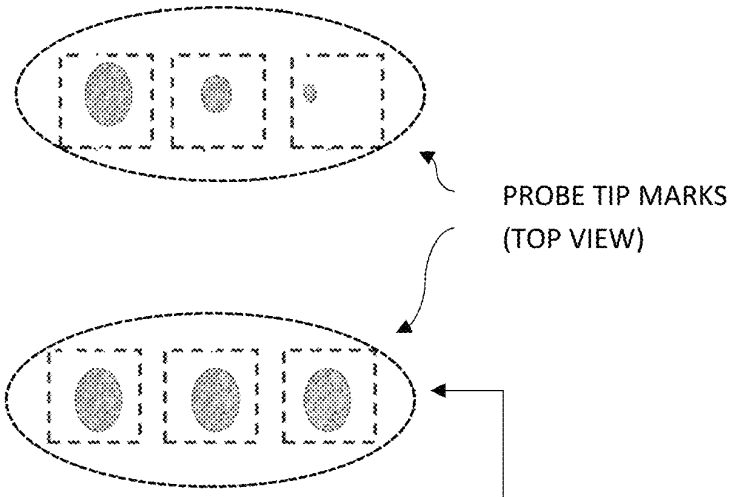
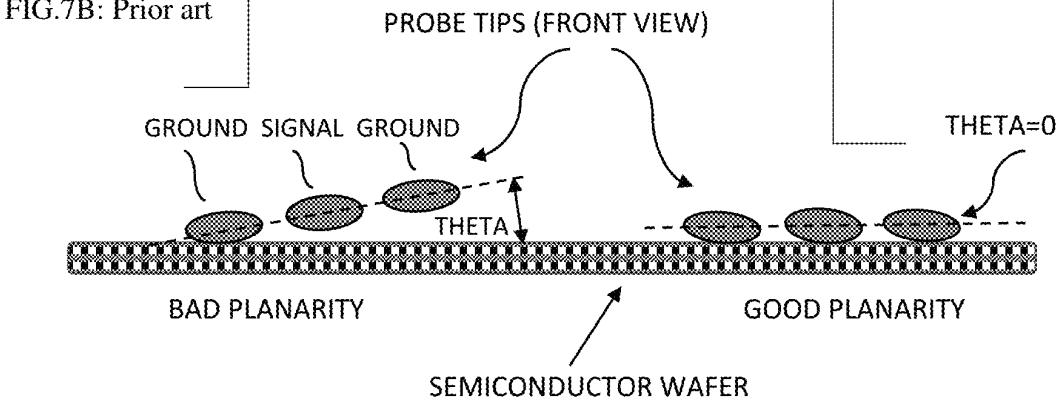



FIG.7B: Prior art



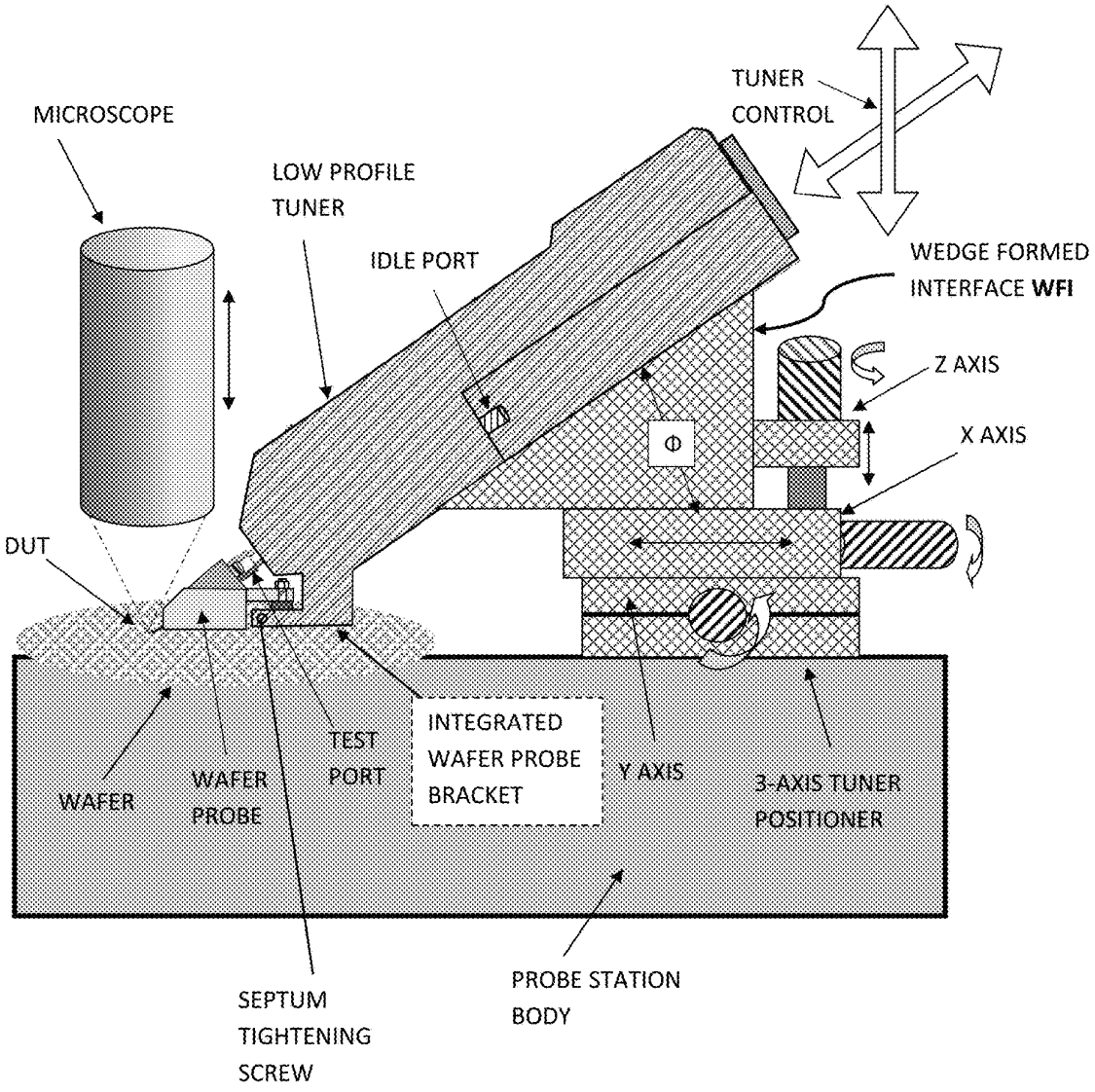

TUNER
CONTROL
MICROSCOPE
LOW PROFILE
TUNER
IDLE PORT
WEDGE FORMED
INTERFACE WFI
Z AXIS
X AXIS
Φ
DUT
WAFER
WAFER
PROBE
TEST
PORT
INTEGRATED
WAFER PROBE
BRACKET
Y AXIS
3-AXIS TUNER
POSITIONER
SEPTUM
TIGHTENING
SCREW
PROBE STATION
BODY

FIG. 8

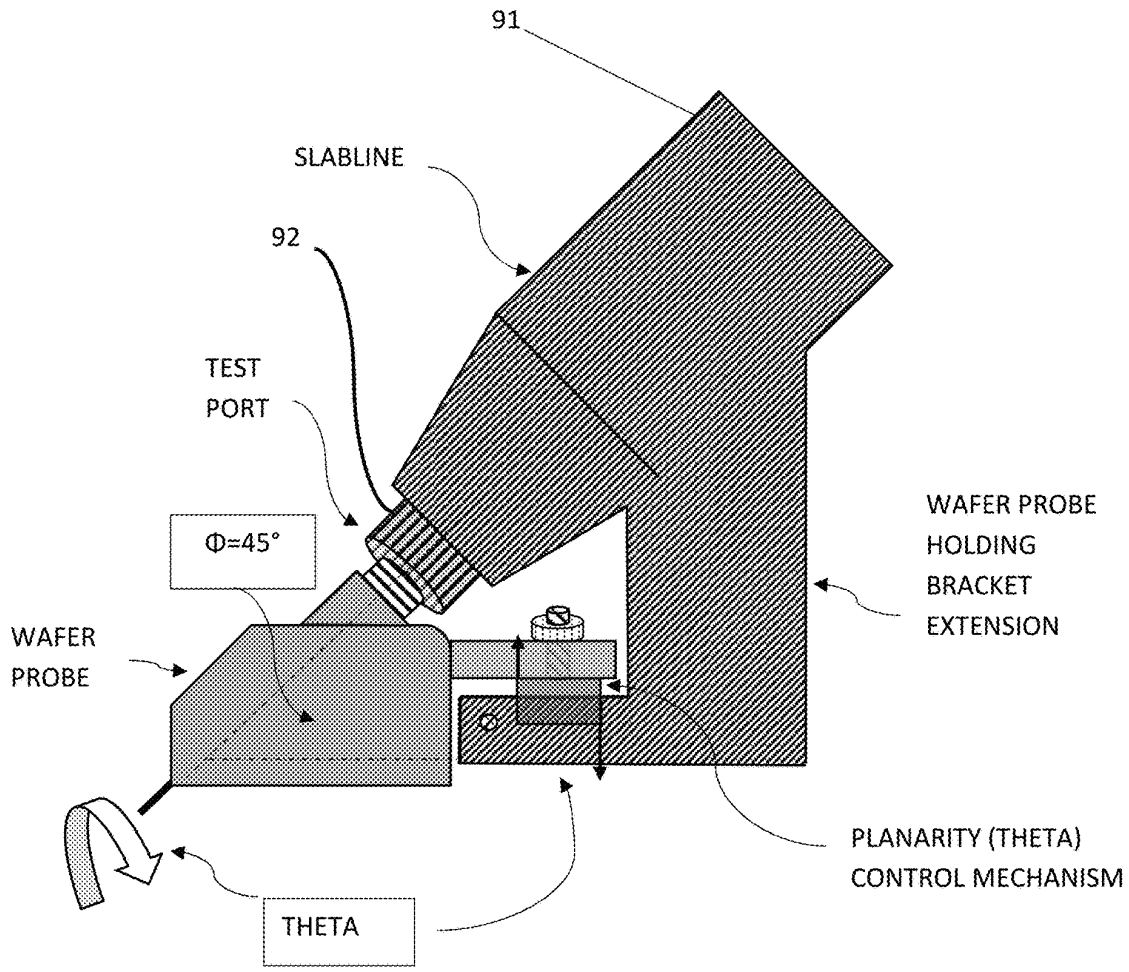

91
SLABLINE
92
TEST
PORT
Φ=45°
WAFER
PROBE
WAFER PROBE
HOLDING
BRACKET
EXTENSION
PLANARITY (THETA)
CONTROL MECHANISM
THETA

FIG. 9

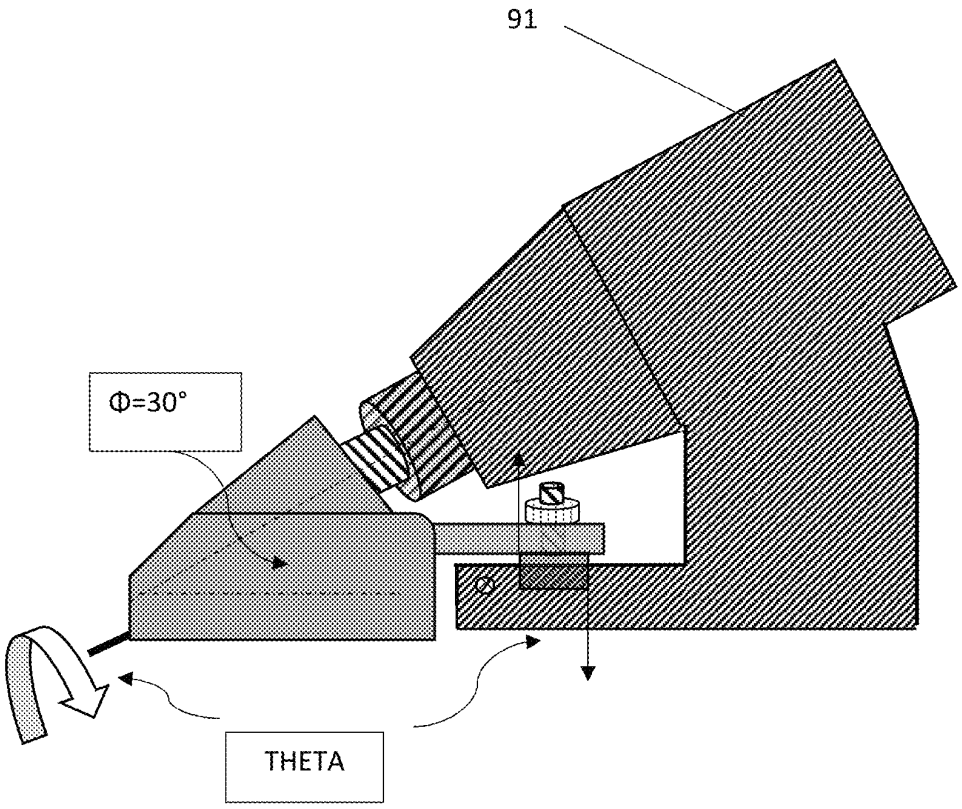



FIG. 10

FIG. 11A

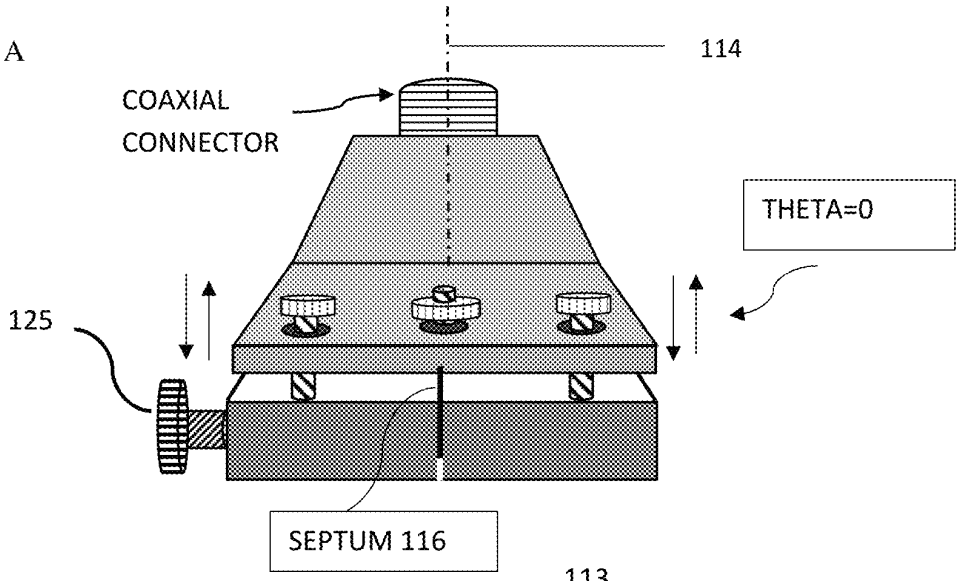



FIG. 11B

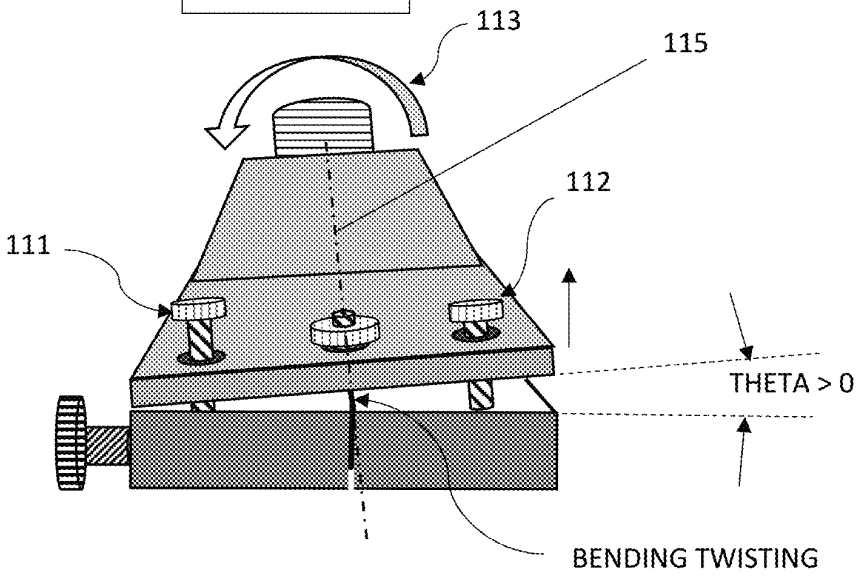
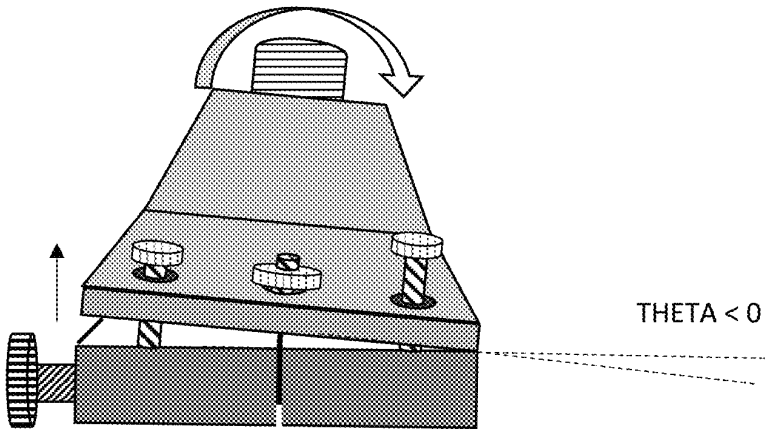



FIG. 11C



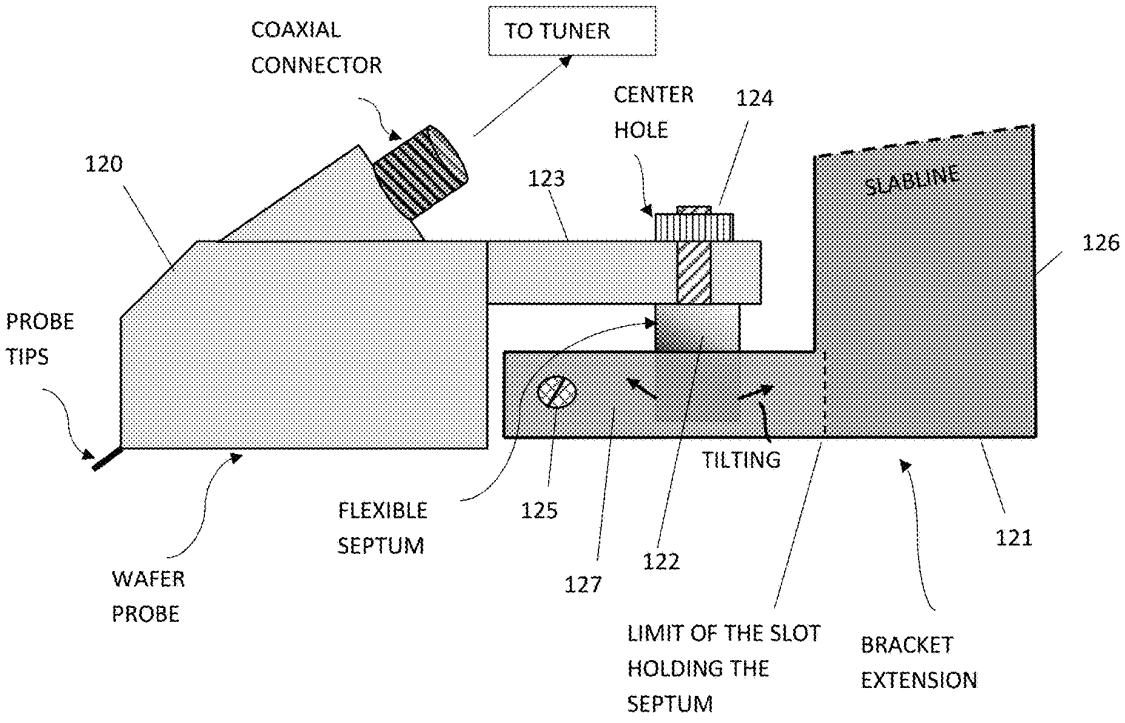

COAXIAL
CONNECTOR
TO TUNER
CENTER
HOLE
124
120
123
SLABLINE
126
PROBE
TIPS
TILTING
FLEXIBLE
SEPTUM
125
121
122
127
WAFER
PROBE
LIMIT OF THE SLOT
HOLDING THE
SEPTUM
BRACKET
EXTENSION

FIG. 12

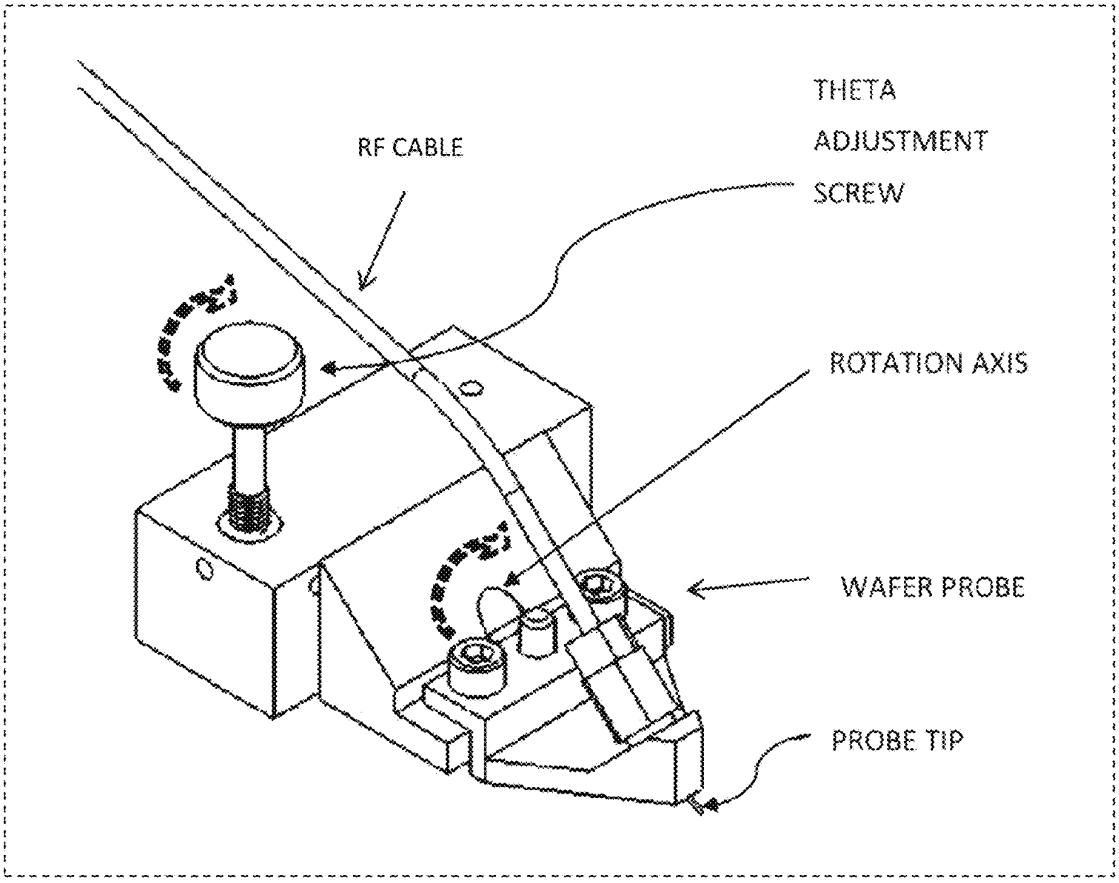



FIG. 13: Prior art

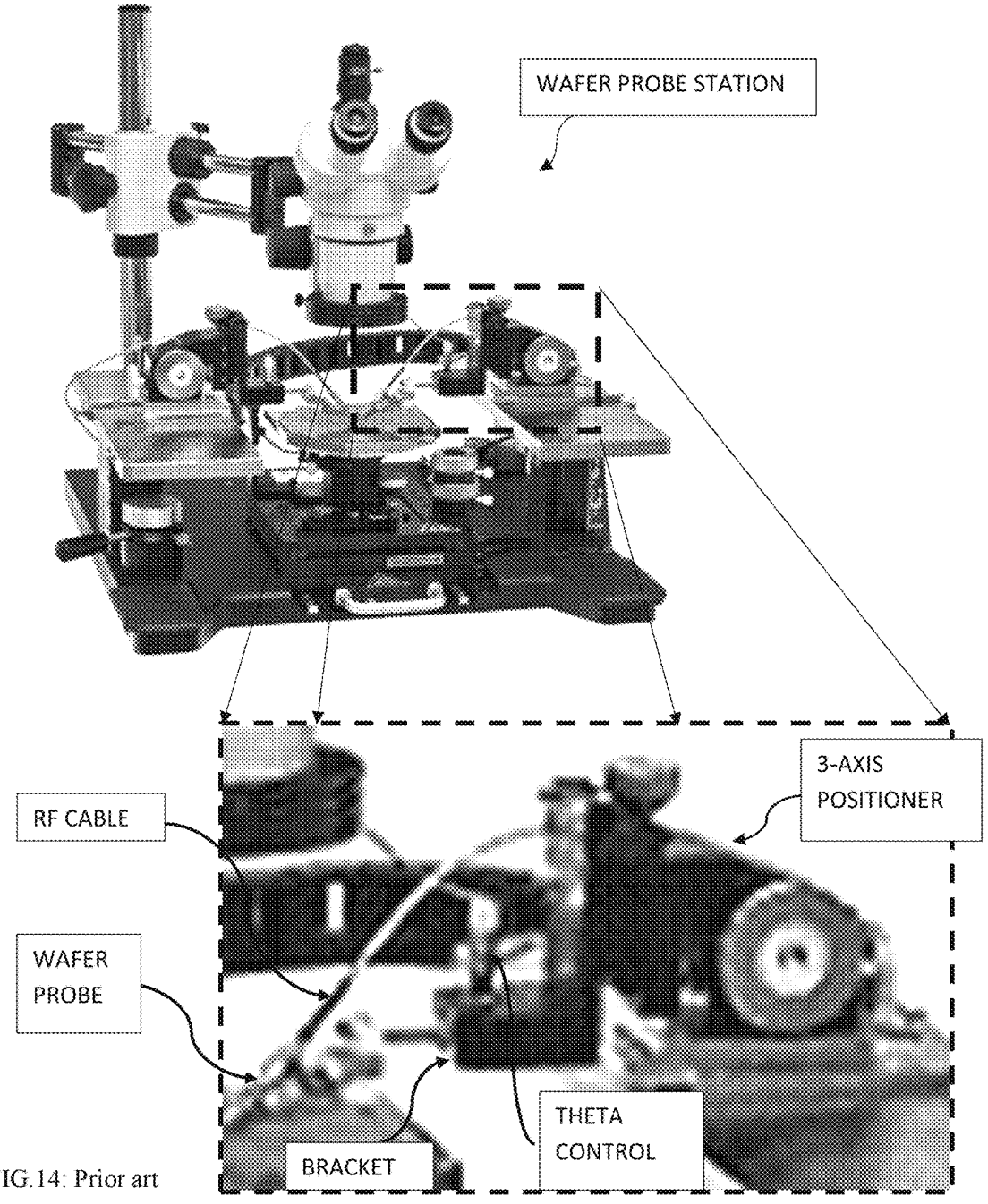



FIG.14: Prior art

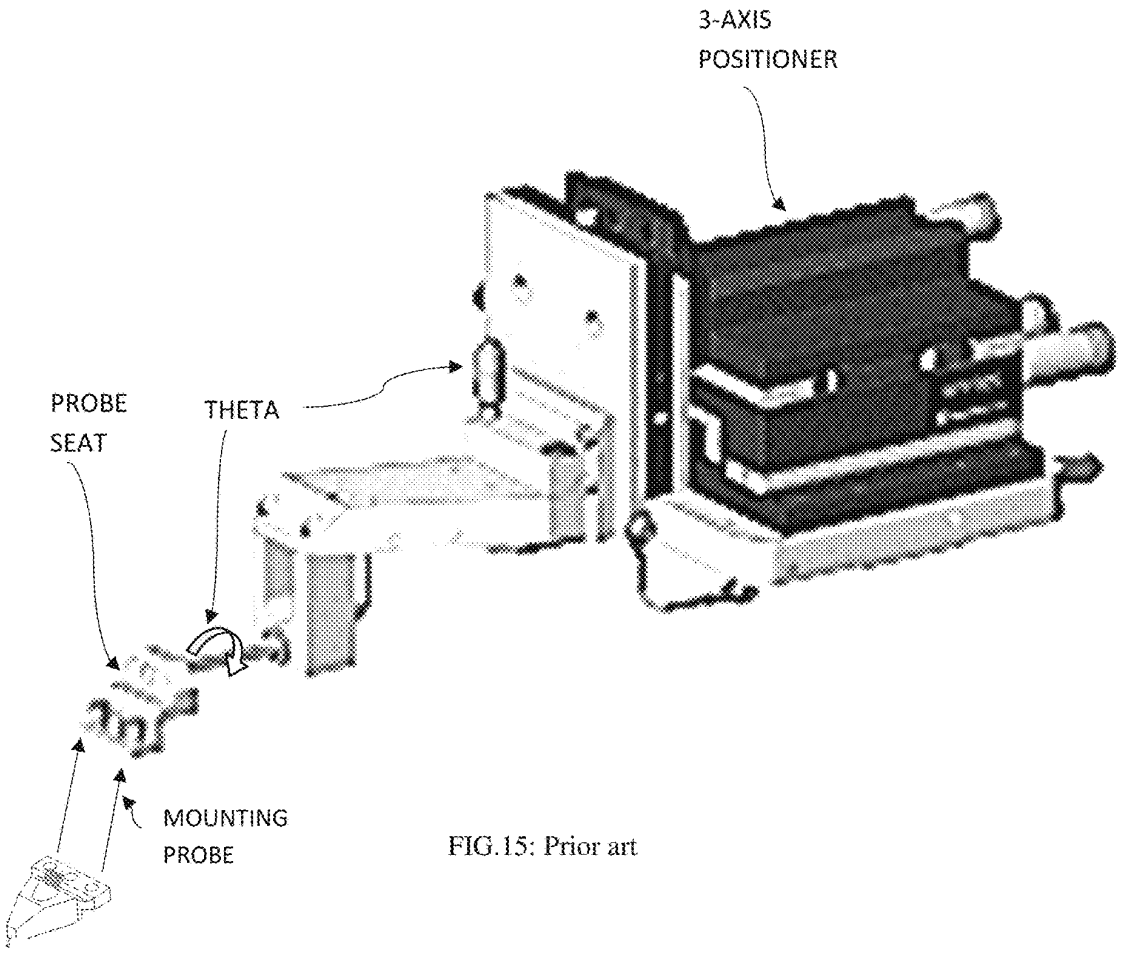



FIG.15: Prior art

FIG. 16A: Prior art

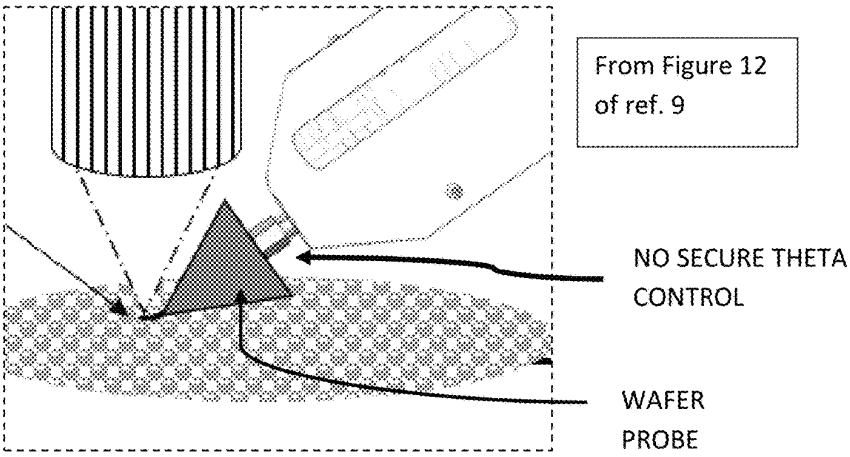



FIG. 16B

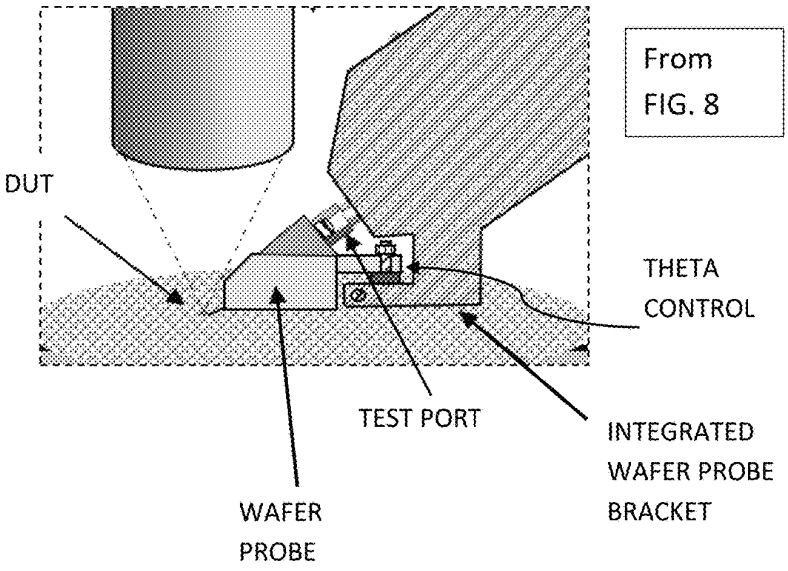
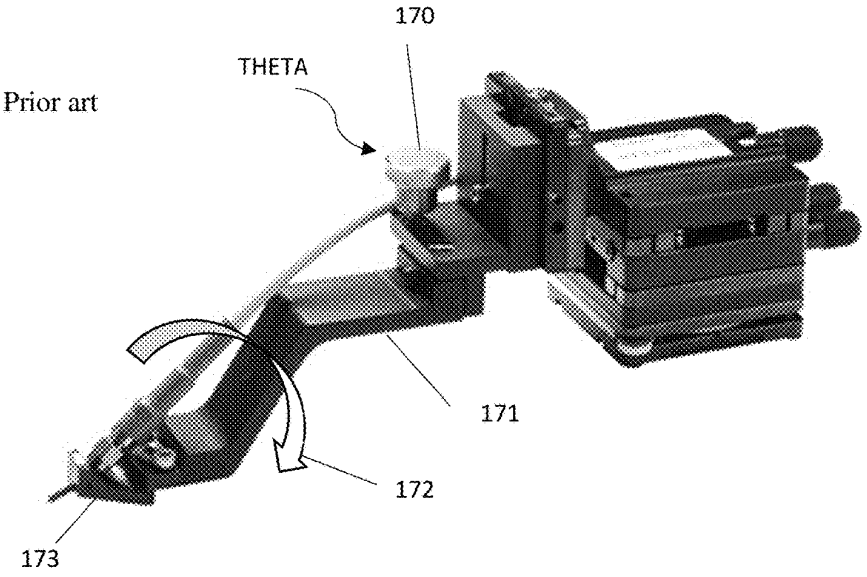


FIG. 17A: Prior art



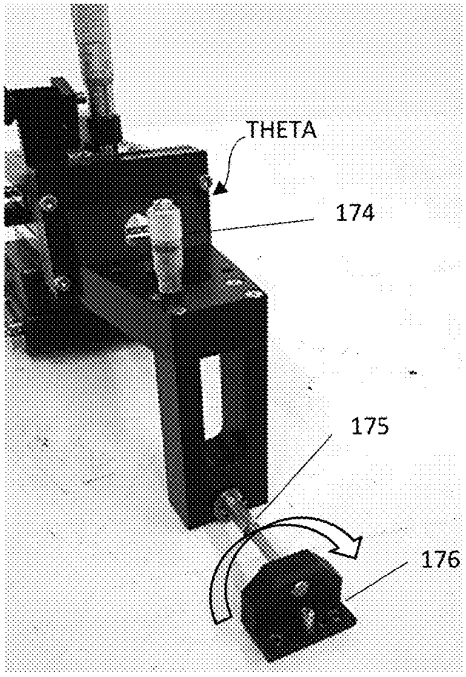




FIG. 17B: Prior art

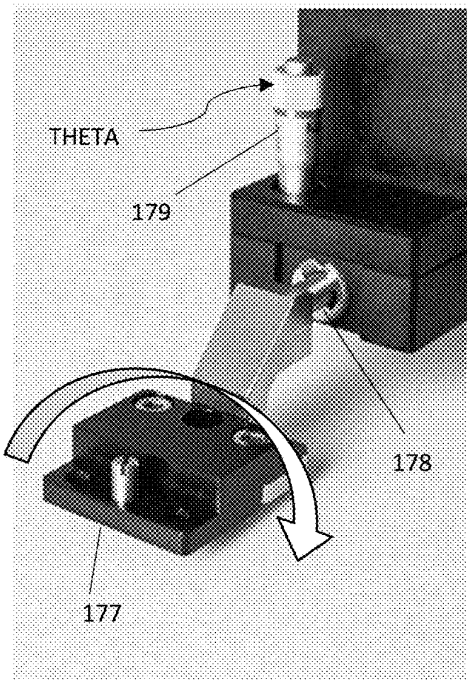



FIG. 17C: Prior art

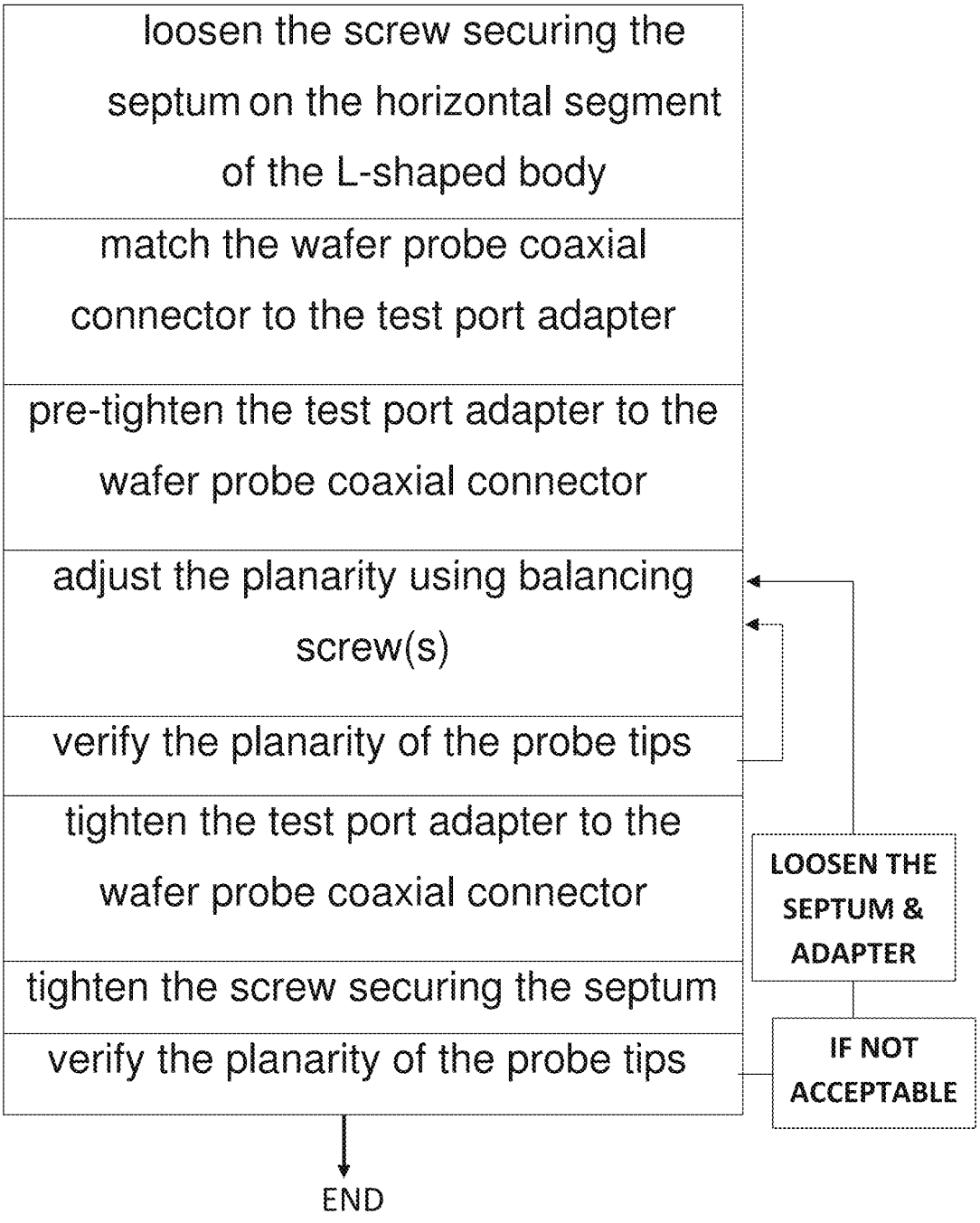

loosen the screw securing the septum on the horizontal segment of the L-shaped body
match the wafer probe coaxial connector to the test port adapter
pre-tighten the test port adapter to the wafer probe coaxial connector
adjust the planarity using balancing screw(s)
verify the planarity of the probe tips
tighten the test port adapter to the wafer probe coaxial connector
tighten the screw securing the septum
verify the planarity of the probe tips
END
LOOSEN THE SEPTUM & ADAPTER
IF NOT ACCEPTABLE

FIG.18

FIG. 19A

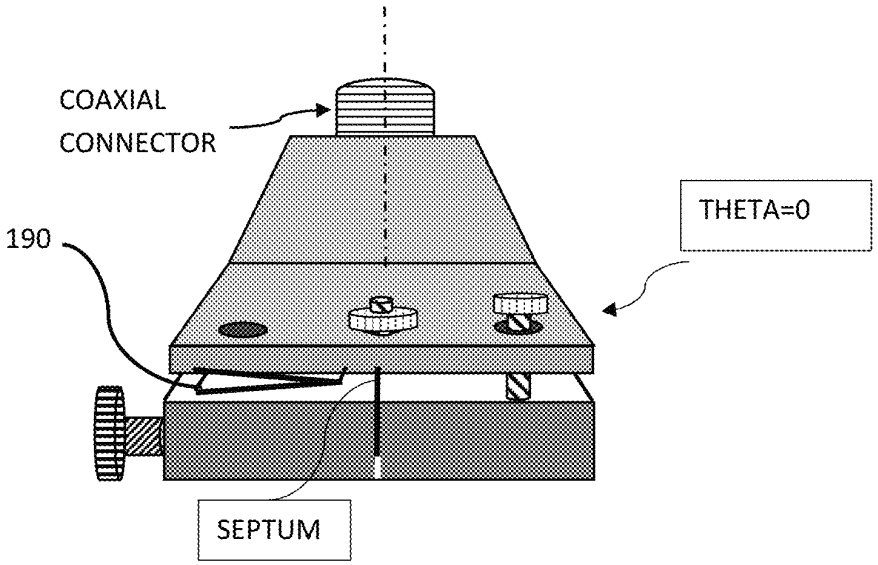



FIG. 19B

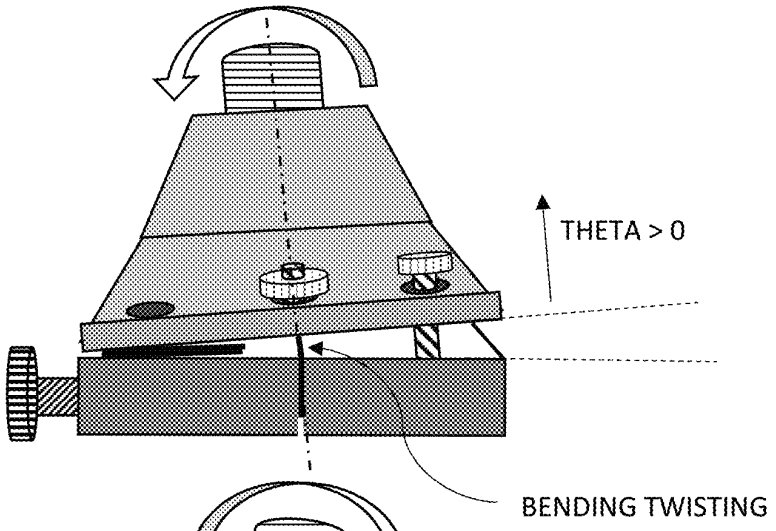
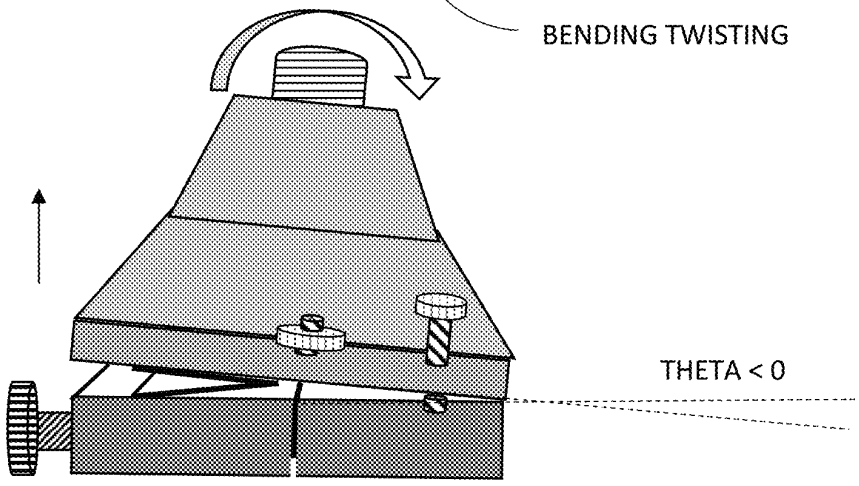



FIG. 19C



# WAFER PROBE INTEGRATION WITH LOAD PULL TUNER

## PRIORITY CLAIM

Not applicable.

## CROSS-REFERENCE TO RELATED ARTICLES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4. Tsironis, U.S. Pat. No. 6,674,293, "Adaptable prematched tuner system and method".
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6. "On Wafer Load Pull Tuner Setups: A Design Help", Application Note 48, Focus Microwaves, December 2001, page 2 ff., FIG. 2.
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8. Load Pull Characterization, White Paper #64, Focus Microwaves Inc., Chapter 2, pp. 13-15, Chapter 9, pp. 43-49.
9. Tsironis, C. U.S. Pat. No. 10,686,239, "Slide screw tuners with offset tuning probes and method", FIGS. 10, 12.
10. Tsironis, C. U.S. Pat. No. 9,335,345, "A Method for Planarity Alignment of Waveguide Wafer Probes".
11. Tsironis, C. U.S. Pat. No. 9,653,332, "Wafer probe holder for planarity and orientation adjustment", FIG. 3.


## BACKGROUND OF THE INVENTION

This invention relates to load and source pull testing of low noise and medium and high-power RF transistor and amplifiers chips on semiconductor wafers using remotely controlled electro-mechanical impedance tuners.

Modern design of low noise and high-power RF amplifiers used in various communication systems, requires accurate knowledge of the active device's (transistor's) characteristics. In such circuits, it is insufficient for the transistors, which operate in their low noise or highly non-linear regime, close to power saturation, to be described using noise or non-linear numeric models only.

A popular method for testing and characterizing such high-power microwave and millimeter-wave transistors (DUT, device under test) is "load pull" (FIG. **1**). Low noise transistors are tested using "source pull". Load or source pull is a measurement technique employing impedance tuners **2**, **4** and other test equipment, such as signal or noise sources **1**, test fixtures housing a DUT **3**, and power meters or low noise receivers **5**, the whole controlled by a computer **6**; the computer controls and communicates with the tuners **2**, **4** and the other equipment **1**, **5** using digital cables **7**, **8**, **9**. The tuners are used in order to manipulate the microwave impedance conditions in a systematic and controlled manner under which the DUT is tested (see ref. 1); impedance tuners allow determining the optimum impedance conditions for designing amplifiers and other microwave components for



specific performance targets, such as noise parameters, gain, efficiency, inter-modulation etc. for devices in chip-form preferably on-wafer (see ref. 6).

Impedance tuners (FIG. **3** and ref. 2 and 9) use, in general, the slide-screw concept, wherein one or more adjustable tuning probes **33** (see ref. 4 and 5) are inserted in a slotted transmission airline (slabline) **32** having two sidewalls, a test port **36** and an idle port, a center conductor **34** (see ref. 4 and FIG. **5**); the tuning probe (slug) **33** is attached to a precision vertical axis **31**, which is mounted in a mobile carriage **38**, using an extension bracket **35**; the axis **31**, controlled by motor **39** can move the probe **33** vertically in Y direction, starting at the top and moving towards the center conductor **34**; the carriage **38** can move the probe **33** horizontally (in X direction) either towards or away from the test port **36** (and the DUT, which is attached to the test port) parallel to the center conductor **34**. The vertical movement Y changes the amplitude of the reflection factor $\alpha$, seen at the tuner test port **36**, whereas the horizontal movement X changes its phase. This way a large portion of the Smith chart (FIG. **2**) is covered, and the high movement resolution of the control mechanics allows synthesizing a large number of impedances from a minimum complex impedance Zmin to a maximum Zmax at any given frequency within the "tuning and frequency range" of the tuner. Typical values of state-of-the-art tuners are Real(Zmin)=2Ω and Real(Zmax)=1250Ω; this corresponds to a Voltage Standing Wave Ratio (VSWR) of 25:1 (see ref. 3). The relation between reflection factor $\Gamma$ and impedance Z is given by

$$\Gamma=|\Gamma|*\exp(j\varphi)=(Z-Zo)/(Z+Zo) \quad \{eq.1\},$$

wherein Z is the complex impedance Z=R+jX and Zo is the characteristic impedance (typically 50 Ohm). $|\Gamma|$ varies between 0 and 1; the intrinsic 22 tuning range $|\Gamma max|$ of the tuner is reduced to the effective 23 tuning range $\Gamma_{DUT}$ at the DUT reference plane by the insertion loss **10**, **11** between the tuner and the DUT (FIGS. **1**, **2** and **5**).

To minimize this insertion loss two prior art methods (see ref. 8 pages 32-33 and ref. 9) have been employed: (a) moving the tuning probe **33** as close to the tuner test port **36** as much as physically possible, and (b) eliminating the RF cable (FIGS. **5** and **13**) by tilting and connecting the tuner directly to the wafer probe (FIGS. **8-10**). To be able to move the tuner body close to the wafer probe and thus eliminating the RF cable (FIG. **5**) one needs to reduce the tuner profile (FIG. **8**). One way for doing this has been described in ref. 9. Herein the vertical stepper motor **39** has been moved behind the carriage **38** and the slabline **32** has been attached externally protruding towards the DUT. A realistic view of the low-profile tuner is shown in FIG. **4**. For practical reasons the housing **37** has been redesigned to include and protect the protruding slabline **32** as shown in FIG. **8**.

However, if the wafer-probe (see ref. 7) is connected to the tuner simply by directly joining the coaxial connector **61** of the probe with the coaxial adapter **92** of the tuner test port, as depicted in FIG. **16**A and (FIG. 10 or 12 of ref. 9), then (a) the joining is not going to be secured and (b) planarity adjustment (FIGS. **7**A and **7**B) is uncontrollable and possible only by feeling the tightening torque applied by hand between the two connectors. A secure method for controlling the planarity is commercially available (FIGS. **13**, **16**, **17**), however, it is cumbersome and requires a lossy RF cable to connect to the tuner (FIGS. **5**, **13**, **17**A), creating this way an insertion loss **10**, **11** and a reduction of the tuning range (FIG. **2**). The optimum overall solution is, therefore, a low-profile tuner as follows:

(i) having protruding tuning probe placed closest to the test port (see ref. 9), as shown in FIG. **3**,
(ii) being mounted at an angle matching the slope of the coaxial connector of the wafer probe and connected directly to it as shown in FIG. **8**, and, in addition to prior art,
(iii) including a secure integrated planarity controlling probe-holding bracket extension as in FIGS. **8-12** and **16**B.

## BRIEF SUMMARY OF THE INVENTION

The invention consists in a new low-profile tuner design integrating a wafer-probe bracket extension with planarity control, that can hold the wafer probe securely, with the impedance tuner mounted on a 3-axis tuner positioner under an angle matching the angle of the axis of the coaxial connector of the wafer probe. The low-profile tuner has its tuning probe operating as close as physically possible to the RF adapter of the tuner test port which is directly connected to the wafer-probe coaxial connector. The new apparatus is not an obvious combination of existing work, because it offers (a) the benefit of increasing, to the maximum possible, the tuning range, (b) the benefit of allowing simultaneous planarity (THETA) control (no prior art allows the combined (a) and (b) configuration, because of the required RF cable), and (c) eliminating the need for the extension RF cable between the instrument (tuner) and the wafer-probe, including the set of two coaxial adapters of the said cable.

The integration of the bracket extension with the tuner slabline is not obvious matter either, because there is no RF cable present, able to absorb the twisting and tilting of the wafer-probe body **116** caused by the planarity adjustment, since the rotation axis **115** of the probe body is different than the rotation axis **114** of the coaxial connector of the probe, shown in FIG. **11**. This incompatibility is absorbed by the twisting, bending and tilting capacity of the flexible septum **116** and the mounting technique employed which uses adjustable positioning of the septum **116** inside the vertical slot **127** and tightening with screw **125**. The slot traverses the horizontal segment of the horizontal segment of the L-shaped bracket extension **126** in which the flexible septum is inserted and is allowed to twist and tilt to absorb even small differences between bracket and probe angles.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The invention and its mode of operation will be more clearly understood from the following detailed description, when read with the appended drawings in which:

FIG. **1** depicts prior art, a typical automated transistor source and load pull test system.

FIG. **2** depicts prior art, effect of insertion loss between tuner and DUT on reducing tuning range at DUT reference plane.

FIG. **3** depicts a front view of a slide screw tuner with horizontally initialized offset tuning probe and a bracket holding the protruding tuning probe.

FIG. **4** depicts a realistic perspective 3D view of the tuning area of the tuner of FIG. **3**.

FIG. **5** depicts prior art, schematic view of wafer probe connected with a load pull tuner using a RF cable and associated items.

FIG. **6** depicts prior art, a perspective view of a commercially available wafer probe and the definition of the angle Φ, being the angle between the axis of the coaxial connector and the plane of the base of the probe body.

FIGS. **7**A through **7**B depict prior art: a magnified view of the probe tips of a wafer probe; FIG. **7**A depicts the probe tip marks on the chip connection pads; FIG. **7**B depicts a front view of the probe tips and definition of planarity angle THETA.

FIG. **8** depicts a low-profile tuner with integrated wafer probe holding bracket mounted on a wafer probe station.

FIG. **9** depicts a conceptual view of the wafer probe and the probe holding bracket integrated with the tuner slabline using Φ=45° wafer probe.

FIG. **10** depicts a conceptual view of the wafer probe and the probe holding bracket integrated with the tuner slabline using Φ=30° wafer probe.

FIGS. **11**A through **11**C depict the THETA planarity control mechanism using two counter balancing screws: FIG. **11**A depicts horizontal position (THETA=0); FIG. **11**B depicts positive THETA; FIG. **11**C depicts negative THETA.

FIG. **12** depicts detail view of the integration of the probe holder (bracket) with the tuner body (slabline) and the wafer probe.

FIG. **13** depicts prior art, commercially available probe holder with THETA control and RF cable.

FIG. **14** depicts prior art, gross and detail view of integration of probe holder with 3-axis positioner.

FIG. **15** depicts prior art, commercially available probe holder with THETA adjustability controlled by 3-axis positioner.

FIGS. **16**A through **16**B are extracts of partly prior art, integration of wafer probe with low-profile tuner; FIG. **16**A depicts prior art: extract of FIG. **12** in ref. 9, low profile tuner connected directly with wafer probe without THETA control. FIG. **16**B depicts extract of FIG. **8**, low profile tuner connected with wafer probe using bracket with THETA control.

FIGS. **17**A through **17**C depict prior art, various commercially available wafer probe positioners with THETA adjustment. They all require RF cable to connect the wafer probes with instruments, or tuners.

FIG. **18** depicts flowchart of THETA alignment and wafer probe securing procedure.

FIGS. **19**A through **19**C depict the THETA planarity control mechanism using a pre-loaded spring: FIG. **19**A depicts horizontal position (THETA=0); FIG. **19**B depicts positive THETA; FIG. **19**C depicts negative THETA.

## DETAILED DESCRIPTION OF THE INVENTION

The load pull system (FIG. **1**) requires at least one impedance tuner **4** or **2** to be connected to the DUT **3** to manipulate the source and/or load impedance. The (typical chip) DUT is accessible through wafer-probes (FIG. **6**). The wafer probes have a coaxial connector **61** leading directly and at minimum insertion loss, using (internally) short microscopic (1 mm) coaxial cable, to coplanar probe tips (FIG. **7**). The angle (between the axis **62** of the coaxial connector **61** and the bottom plane **63** of the body of the wafer probe is a characteristic quantity of the probe (FIGS. **9** and **10**). There are wafer probes with (equal 30, 45 or 90 degrees (see ref. 7); this invention deals with 30- and 45-degree probes.

Insertion loss **10**, **11** of the connection paths between the tuners **4**, **2** and the DUT **3** reduce the tuning range **22** at the tuner plane to the effective tuning range **23** at the DUT plane. The result is that a typical internal impedance **20** of the DUT cannot be conjugate matched, except if the insertion loss **10**, **11** is minimized. In extreme cases, DUT with

internal impedance **21** close to the limit of the Smith chart cannot be matched at all using passive tuners, instead requiring active tuning (see ref. 8). To reach tuning range close to **22** one has to minimize all insertion loss **10**, **11** and place the tuning probe of the tuner as close to the test port as possible. This is shown in FIGS. **3** and **8**.

FIG. **3** depicts the conceptual layout of a prior art low-profile tuner of ref. 9: In this case the tuning probe **33** is held by an extension bracket **35** and brought as close (L**1**) to the test port connector **36** of the tuner as mechanically possible. For this the slabline **32**, including the center conductor **34**, has been mounted protruding towards the DUT (test port **36**) externally to the tuner housing **37**, in order to gain room otherwise taken by the width of the mobile carriage **38** and the vertical axis **31** leading to a larger minimum distance L**0**. This way the linear insertion loss inside the tuner, between the tuning probe **33** and the test port **36** is reduced by a factor L**0**/L**1**. An actual 3D drawing of the tuner active area is shown in FIG. **4**.

In hitherto art (FIG. **12** of ref. 9) the wafer probe was connected to the tuner by simply screwing and tightening the coaxial connector **61** to the tuner test port adapter **92** using some supporting alignment tool (see ref. 10) to planarize (adjust the angle THETA) the wafer probes, as shown in FIGS. **7**A and **7**B. Extract of the prior art method is shown in FIG. **16**A and compared with extract of the new method in FIG. **16**B. The planarity adjustment method in FIG. **16**A is obviously based on personal feeling and trial and error, since tightening the connectors by hand may change the angle THETA. The correct approach should be to adjust and fix the planarity of the wafer-probe base using mechanical precision (fine thread screws) after tightening the connectors. This is shown in FIGS. **11** and **12**.

FIG. **12** shows the wafer probe body **120** supported by the L-shaped slabline extension forming the wafer probe bracket, of which the horizontal segment **121** is attached underneath the probe overhang **123** and continues as the slabline of the tuner upwards **126**. The link between the overhang **123** of the wafer probe and the horizontal segment **121** of the bracket is a flexible, preferably steel, thin septum **122**, which is firmly attached to the wafer probe overhang **123** using screw **124**. The horizontal segment **121** of the bracket extension is slotted vertically parallel to the slabline axis up to the limit **127** and the septum **122** is inserted in the slot and secured using perpendicular screw **125**, which tightens the slot's jaws, after final planarity adjustment (FIG. **18**). The space **110** (FIG. **10**) between the bottom of the overhang **123** and the top of the bracket extension is left free to allow some twisting and bending of the septum **122** (FIG. **11**) to allow absorbing small amounts of twisting, bending and tilting created by the rotation of the coaxial connector **113** against the nominal rotation axis of the body **114**, since their rotation axes are slightly different. This allows for the septum **122** to be inserted, tilted, twisted, moved to the right position and secured using screw **125** after the coaxial connector of the wafer probe is pre-tightened to the coaxial adapter of the tuner test port **92** (FIGS. **4**, **8** and **9**). The screw **124** holding the septum **122** is inserted into the center hole **60** of the wafer probe overhang **64**, **123**, while the remaining two holes of the overhang receive the two planarity controlling counter-balancing screws **111** and **112** (FIG. **11**B). In an alternative embodiment (FIG. **19**) one of the two counter-balancing screws **111** or **112** is replaced by a strong folded steel spring **190**, preloaded to lift one side of the probe overhang against the opposite side and thus facilitating the alignment and allowing for continuous precise and secure planarity control using a single screw. The three extreme planarity settings are shown in FIG. **11**A through **11**C and FIGS. **19**A through **19**C: FIGS. **11**A/**19**A shows balanced setting (THETA=0), FIGS. **11**B/**19**B shows maximum positive THETA and FIGS. **11**C/**19**C shows maximum negative THETA. Typical maximum values of THETA range settings is ±5° to ±7°.

The THETA alignment and securing procedure (depicted in the flowchart of FIG. **18**) proceeds as follows: (a) the screw **125**, securing the septum **122**, is loosened; (b) the wafer probe with the septum **122**, secured on the overhang **123**, is inserted and connector **61** is screwed (but not yet tightened) on the test port adapter **92** of the already in nominal slope (angle (D) mounted and positioned tuner; (c) the screws **111** and **112** (or one screw against the force of the pre-loaded spring **190**) are/is adjusted for the THETA angle to compensate any wafer probe tips mis-planarity (this is done under microscope by observing the initial contact marks on a chip contact pad, as shown in FIG. 7A and FIG. 3 of ref. 11); (d) the tuner test port adapter is tightened on the coaxial connector **61**; (e) the screws **111** and/or **112** are/is tightened; (f) the septum **122** is secured using screw **125** and the planarity verified as in step (c). The procedure is repeated until the verification of step (c) provides acceptable planarity. During this procedure the septum **122** will be tilted and bent inside the slot of the horizontal segment **121** and slightly twisted after tightening the screw **125**. This procedure allows secure, permanent, mechanically fine positioning for acceptable planarity of the wafer probe tips.

FIGS. **9** and **10** show tuner and probe mounting configurations for 45° and 30° wafer probes. The settings are equivalent, provided that the slabline **91** of the tuner has the appropriate bracket extension integrated and tuner itself has been pivoted by the 3-axis positioner to match the wafer probe angle and held in place using a large tuner wedge-formed interface WFI (FIG. **8**).

FIGS. **13**-**17** aid to emphasize the differences between the proposed apparatus and prior art: FIG. **13** shows a commonly available solution. This configuration, as all known alternatives shown in FIGS. **14**, **15** and **17**A through **17**C, do not allow direct attachment of the wafer probe to external instruments, which, in particular for electro-mechanical passive impedance tuners, is prohibitive, due to the already discussed insertion loss of the required RF cables. Even though the RF cables are shown only in FIGS. **13**, **14** and **17**A, they are always required. FIGS. **17**A through **17**C show a number of variants, all using the same principle: Screw **170** in FIG. **17**A, tilts the link **171** and thus the THETA angle **172** of the wafer probe **173**. In FIG. **17**B the micrometric screw **174** rotates the axis **175** using an internal, not shown, mechanism and the probe seat **176** with the same effect. In FIG. **17**C the micrometric screw **179** does the same to the probe seat **177** via the axis **178**.

Obvious alternative embodiments to the herein disclosed apparatus and method combining (a) low profile slide screw tuners, which use extension brackets for the tuning probes, (b) the method of mounting the tuners on probe stations for perfect alignment and direct contact with the wafer probes maximizing this way the tuning range, (c) integrating and the method for planarity adjusting a wafer probe bracket, are imaginable and possible, but shall not impede on the validity of the basic idea of the present invention.

What is claimed is:

**1**. A low-profile load pull tuner for on-wafer operation, comprising:

a) a low-profile housing including electronic interface, at least one mobile carriage remotely controlled by stepper motor(s) and gear, and

b) a slabline comprising:
i) two sidewalls,
ii) a center conductor, a test port with an adapter and an idle port, wherein
the at least one mobile carriage slides parallel to the center conductor and has a remotely controlled, perpendicular to the center conductor moving axis, holding a metallic tuning probe insertable between the sidewalls,
iii) a bracket extension holding a wafer probe and controlling its planarity;
wherein
the low-profile tuner is mounted at an angle Φ matching an angle of the wafer probe, and
the adapter of the test port of the slabline is connected directly to the wafer probe;
and wherein
the wafer probe is attached to the bracket extension using a vertical flexible septum and a control mechanism of the planarity (THETA) of the wafer probe.

**2**. A method for mounting the low-profile load pull tuner of claim **1** on a wafer probe-station for highest tuning range at a DUT reference plane,
wherein
the low-profile tuner is mounted on a 3-axis positioner using a wedge-formed interface (WFI) matching the angle Φ of the wafer probe, whereby the adapter of the test port of the slabline is screwed directly on a coaxial connector of the wafer-probe.

**3**. The low-profile load pull tuner of claim **1**,
wherein
the wafer probe comprises a body, a coaxial connector, an overhang and probe tips, the overhang having three vertical holes, a center hole and two side holes, all three holes being aligned perpendicular to an axis of the coaxial connector of the wafer probe;
and wherein the bracket extension holding the wafer probe comprises:
a L-shaped body having a horizontal and a vertical segment,
a vertical flexible septum,
a planarity controlling mechanism;
and wherein
the horizontal segment of the L-shaped body is attached from underneath to the wafer probe overhang using the vertical septum, which is held by a screw through the center hole of the overhang,
and wherein
the planarity controlling mechanism comprises two counter-balancing screws inserted into the side holes of the overhang pushing against the horizontal segment of the L-shaped body.

**4**. The low-profile load pull tuner of claim **1**,
wherein
the wafer probe comprises a body, a coaxial connector, an overhang and probe tips, the overhang having three vertical holes, a center hole and two side holes, all three holes being aligned perpendicular to an axis of the coaxial connector of the wafer probe;
and wherein the bracket extension holding the wafer probe comprises:
a L-shaped body having a horizontal and a vertical segment,
a vertical flexible septum,
a planarity controlling mechanism;
and wherein
the horizontal segment of the L-shaped body is attached from underneath to the wafer probe overhang using the vertical septum, which is held by a screw through the center hole of the overhang,
and wherein
the planarity controlling mechanism comprises one balancing screw inserted into one side hole of the overhang and a pre-loaded spring inserted between an area below the other side hole and the horizontal segment of the L-shaped body.

**5**. A method for aligning and securing the wafer probe attached to the bracket extension of the low-profile load pull tuner of claims **3** or **4**, comprising the following steps:
a) loosen a screw securing the septum on the horizontal segment of the L-shaped body;
b) match and pre-tighten the test port adapter to the coaxial connector of the wafer probe;
c) adjust the planarity using the balancing screw(s);
d) verify the planarity of the probe tips;
e) if the planarity is not acceptable go to step c);
f) tighten the test port adapter to the coaxial connector of the wafer probe;
g) verify the planarity of the probe tips;
h) if the planarity is not acceptable, loosen the test port adapter and go to step c);
i) tighten the screw securing the septum.

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