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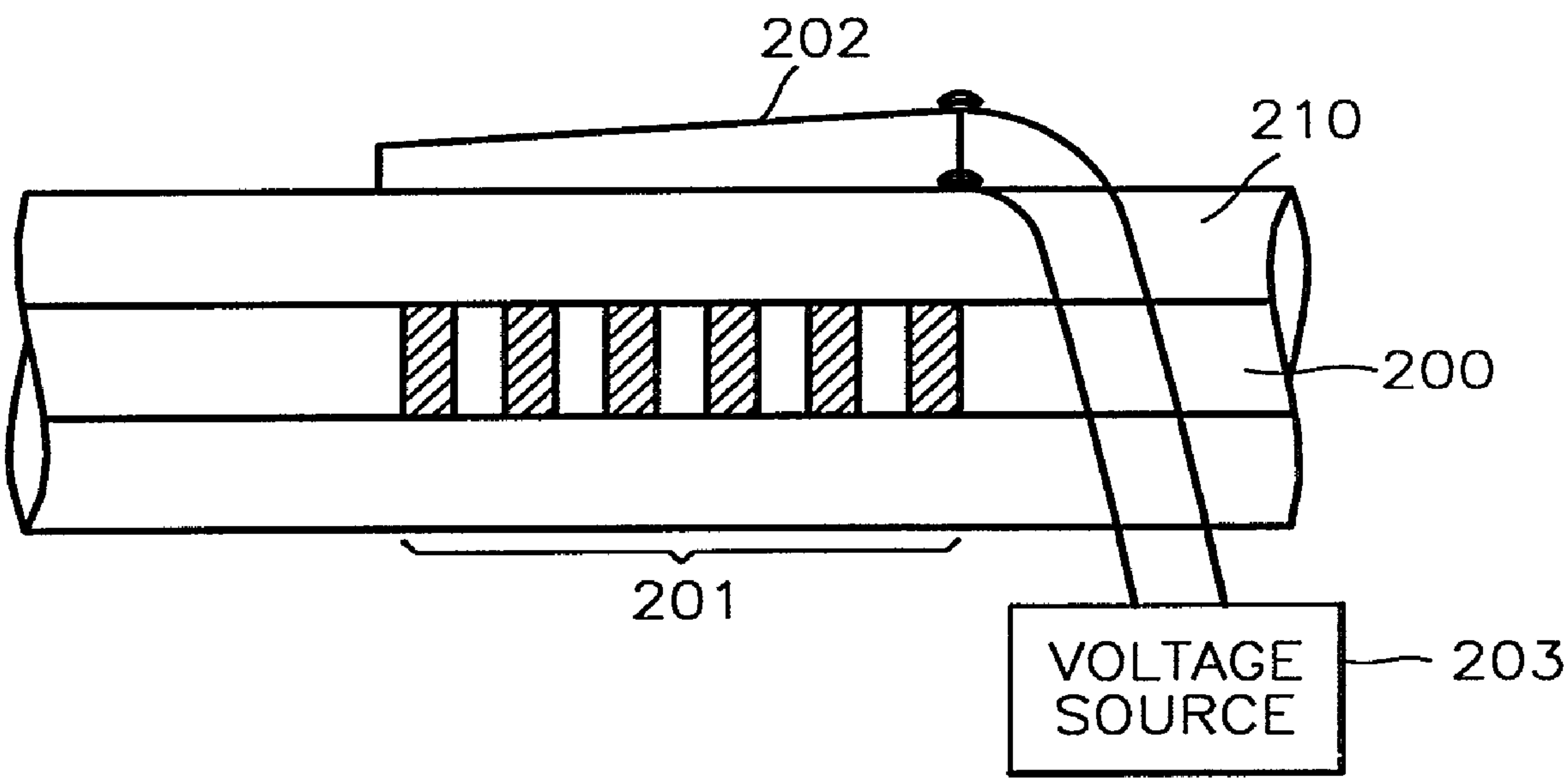
(54) Title: TUNABLE CHIRPED FIBER GRATING DEVICE AND METHOD FOR FORMING CHIRPED FIBER GRATING




(57) Abrégé/Abstract:
A tunable chirped grating device an optical fiber having the same spacings between index perturbations, a piezoelectric element bonded to the optical fiber, for changing the perturbation spacings according to an applied voltage, and a voltage source for applying the voltage to the piezoelectric element. Since a predetermined piezoelectric element is bonded to an optical fiber provided with a grating having regular spacings and the perturbation spacings can be differently deformed by applying different electric field to respective perturbation positions by the piezoelectric element, and the chirping rates of the reflected wavelengths waves can be adjusted, a chirped grating device whose manufacturing procedure is simple and which has flexibility can be provided.

## Abstract of the Disclosure

A tunable chirped grating device an optical fiber having the same spacings between index perturbations, a piezoelectric element bonded to the optical fiber, for changing the perturbation spacings according to an applied voltage, and a voltage source for applying the voltage to the piezoelectric element. Since a predetermined piezoelectric element is bonded to an optical fiber provided with a grating having regular spacings and the perturbation spacings can be differently deformed by applying different electric field to respective perturbation positions by the piezoelectric element, and the chirping rates of the reflected wavelengths waves can be adjusted, a chirped grating device whose manufacturing procedure is simple and which has flexibility can be provided.

# TUNABLE CHIRPED FIBER GRATING DEVICE AND METHOD FOR FORMING CHIRPED FIBER GRATING

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a tunable chirped fiber grating device in which the spacings of perturbations in the index of refraction vary with a strain which is produced by applying a voltage across a predetermined piezoelectric element and a method for forming a chirped fiber grating.

2. Description of the Related Art

A chirped grating is designed to have different perturbation spacings or different effective refractive indices depending on positions of the perturbations, and is characterized in that the wavelength of reflected light differs depending on the positions of the perturbations. FIGS. 1A and 1B show side views illustrating an optical fiber in which a chirped grating is formed. Here, a core is represented by reference numeral 100 or 120, a cladding by 110 or 130, and a grating by 101 or 102. The chirped grating 101 in the core 100 according to FIG. 1A has a structure in which the spacings of successive perturbations are different from each other, while the effective refractive indices of the perturbations are the same, and a chirped grating 102 in the core 120 according to FIG. 1B has a structure in which the spacings of successive perturbations are the same, while the effective refractive indices of the perturbations are different from each other.

However, such chirped gratings are doomed to experience more complicated procedures than those having equal perturbation spacings, and since the chirping rates of the reflected wavelengths according to the positions of the perturbations are fixed to values in fabrication conditions and therefore the gratings can be used for a specific wavelength band, and the gratings cannot be applied flexibly.

## SUMMARY OF THE INVENTION

To solve the above problem, it is an objective of the present invention to provide a tunable chirped grating device whose perturbation spacings differ from each other by attaching an element whose length can vary with an applied voltage to an optical fiber including a grating in which spacings between perturbations are are regular and controlling the applied voltage, and a method for forming a chirped fiber grating.

Accordingly, to achieve the above objective, there is provided a tunable chirped grating device characterized in that the tunable chirped grating device includes an optical fiber having the same spacings between index perturbations, a piezoelectric element bonded to the optical fiber, for changing the perturbation spacings according to an applied voltage, and a voltage source for applying the voltage to the piezoelectric element.

To achieve the above objective, there is provided a method for forming a chirped fiber grating characterized in that the method includes the steps of (a) forming a grating having regularly spaced perturbations in the optical fiber, and (b) causing the perturbation spacings of the optical fiber grating to differ from each other by applying different tensions to the optical fiber grating according to the positions of the perturbations.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above objective and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIGS. 1A and 1B are side views illustrating an optical chirped grating is formed; and

FIG. 2 is a side view illustrating the structure of a tunable chirped grating device according to the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 2 shows a side view illustrating the structure of a tunable chirped grating device according to the present invention. The tunable chirped grating device shown in FIG. 2 includes an opticla fiber in which a grating 201 having perturbations which have the same refractive index perturbations and regularly spaced therebetween in a core 200 formed inside a cladding 210, a piezoelectric element 202 attached to the optical fiber, and a voltage source 203 for supplying a voltage to the piezoelectric element 202.

A method for forming a chirped grating using the above described structure is as follows. That is, the grating 201 having regularly spaced perturbations is formed in the optical fiber core 200, and the spacings of perturbations are caused to differ from each other by applying different tensions to the optical fiber grating 201 according to the positions of the perturbations. The tensions are created by the piezoelectric element 202 and the voltage source 203.

The grating 201 satisfies the following Bragg condition in the optical fiber core 200.

$$\lambda_i = 2 \cdot n_{eff} \cdot d_i$$

where $\lambda_i$ is the wavelength of an incident wave, $n_{eff}$ is the effective index of refraction, and $d_i$ is the spacing between perturbations.

The material of the piezoelectric element 202 attached on the outside of the grating 201 is a material which can be deformed according to the voltage applied by the voltage source 203, and $Pb(Zr_x Ti_{1-x})O_3$, $0.4 \le x \le 0.6$ (PZT or Lead Zirconate Titanate) is preferably appropriate for the material. Epoxy may be used as the adhesive. The piezoelectric element 202 made of a material such as PZT deforms in a direction perpendicular to the applied electrical field. The shape of the piezoelectric element 202 is preferably wedge-shaped in order for deformations at each position to occur with different degrees from each other according to the applied voltage. That is, though the applied voltage is constant, as a portion of the piezoelectric element 202 is thicker, the electrical field becomes relatively weaker than a thinner portion. As a result, the thinner portion deforms to a smaller extent than the thicker portion.

The perturbation spacings of the grating 201 bonded to the piezoelectric element 202 having the above-described characteristics vary with the deformation of the piezoelectric element 202. Consequently, a chirped grating device having different spacings between perturbations can be formed. Further, when the voltage applied by the voltage source 203 is adjusted, the chirping rates of the reflected wavelengths can be adjusted.

According to the present invention, since a predetermined piezoelectric element is bonded to an optical fiber provided with a grating having regular perturbation spacings and the perturbation spacings can be differently deformed by applying different electrical fields to respective perturbation positions by the piezoelectric element, and the chirping rates of the reflected wavelengths can be adjusted, a chirped grating device whose manufacturing procedure is simple and which has flexibility can be provided.

**CLAIMS**:

1. A tunable chirped grating device comprising:

an optical fiber having equal spacings between index perturbations of a chirped grating:

an elongated piezoelectric element having one end with a thickness greater than an opposite end in the longitudinal direction, bonded to the optical fiber, for varying the spacings between the perturbations in response to an applied voltage; and

a voltage source for applying the voltage to the piezoelectric element.

2. The tunable chirped grating device as claimed in claim 1, wherein the material of the piezoelectric element is $Pb(Zr_xTi_{1-x})0_3$.

3. The tunable chirped grating device as claimed in claim 1, wherein the piezoelectric element is wedge-shaped and is bonded to the optical fiber using an epoxy.

4. A method for forming a chirped grating including the steps of:

forming a grating having regularly spaced perturbations in a core of an optical fiber;

bonding a wedge-spaced piezoelectric device to said optical fiber adjacent said grating; and

stretching said optical fiber by applying a controlled voltage to said wedge-shaped piezoelectric device in order to vary the spacings between the perturbations.

5. The method as claimed in claim 4, wherein said step of stretching applies different tensions to said optical fiber according to a variation in thickness of said wedge-shaped piezoelectric device.

FIG. 1A (PRIOR ART)

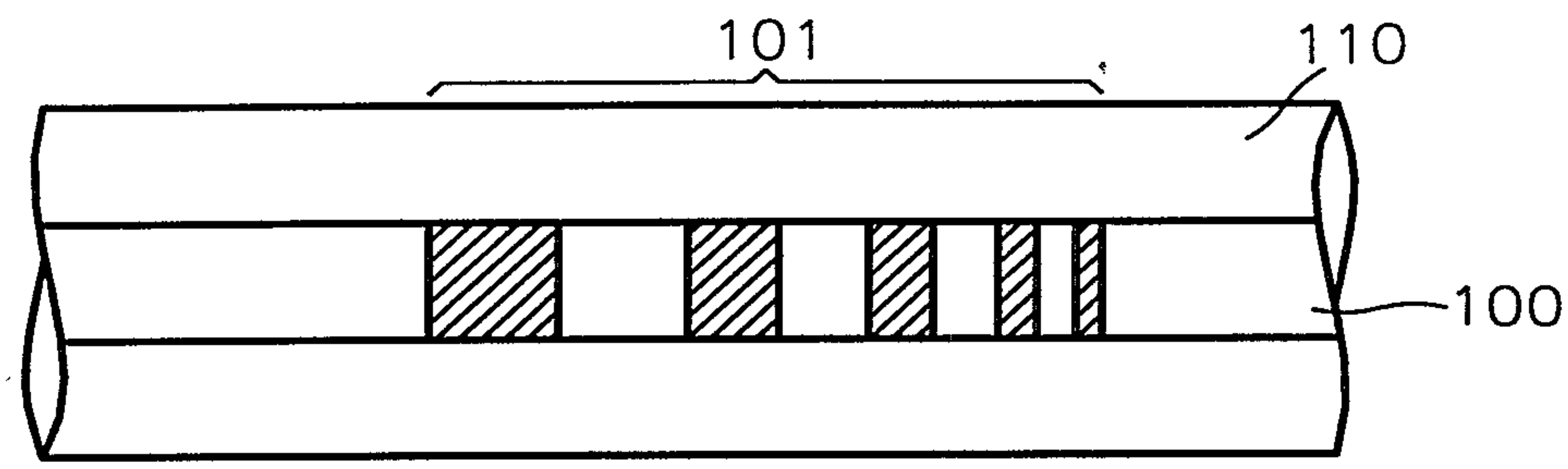



FIG. 1B (PRIOR ART)

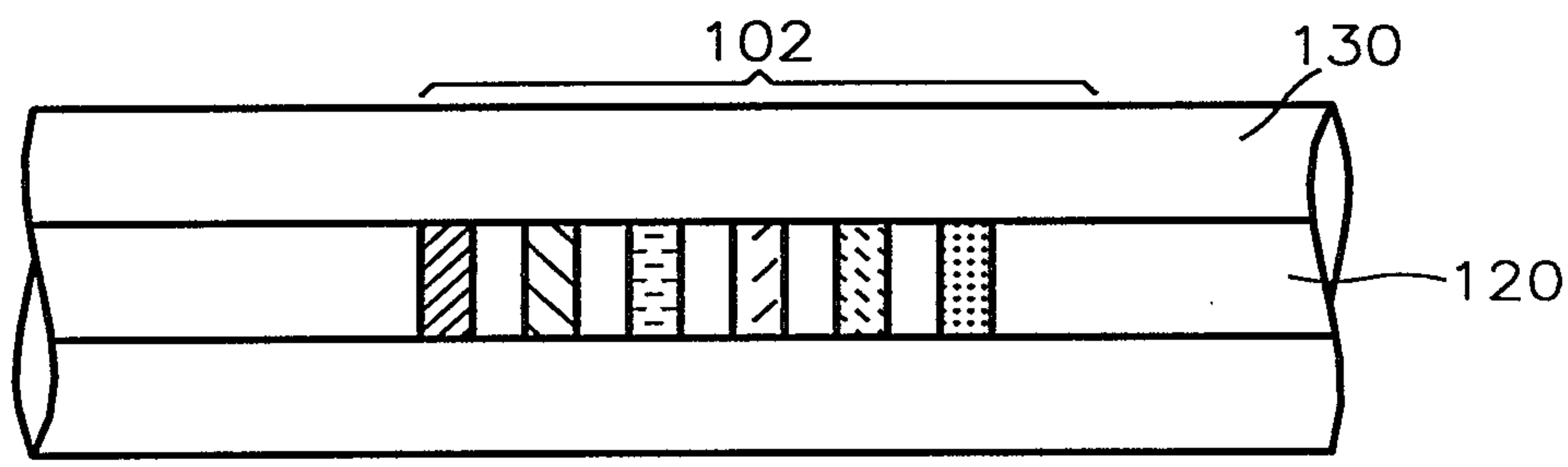
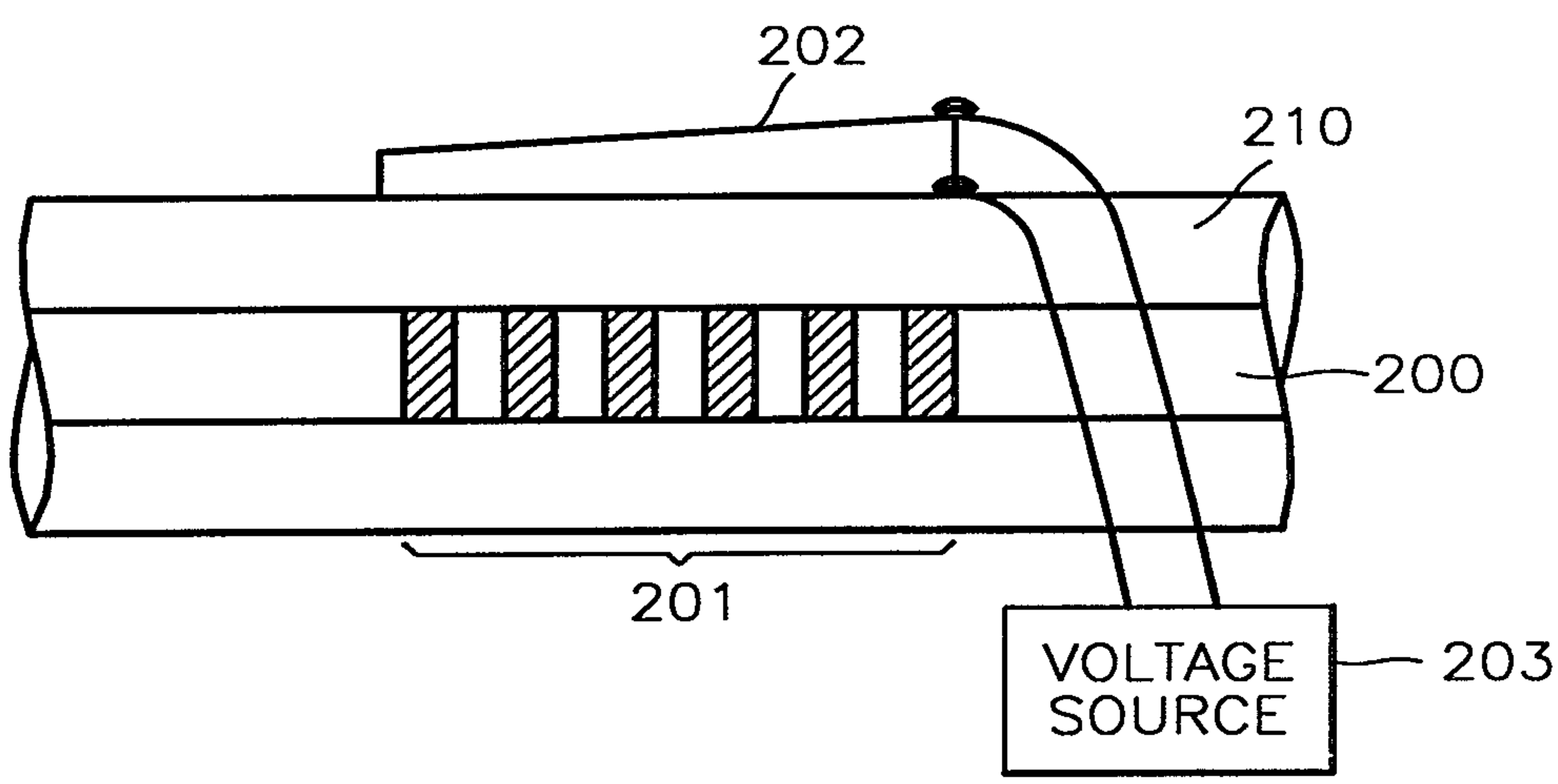
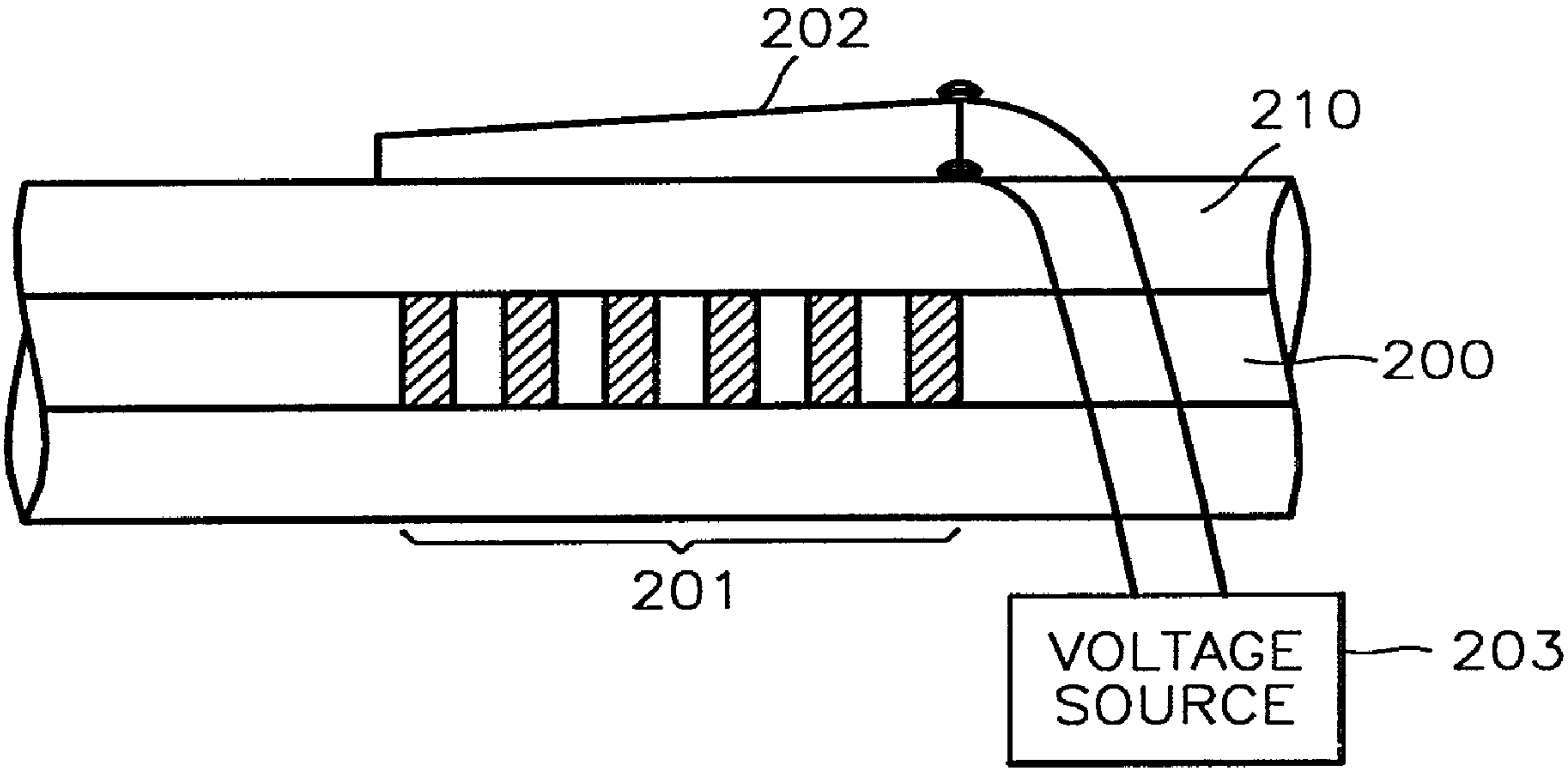



FIG. 2

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