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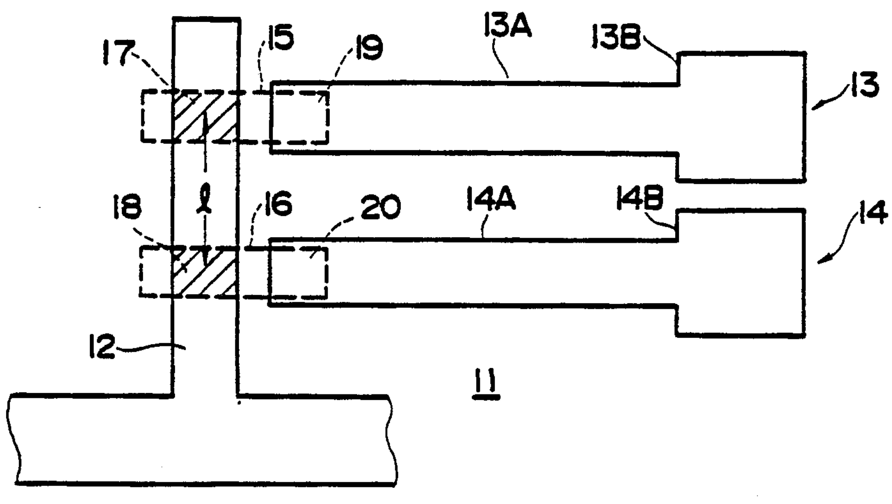
(54) **Microwave integrated circuit.**

(57) In this invention, a distributed constant line (12) of a microwave IC is formed of a Schottky metal, and a semiconductor conductive layer (15,16) contacting the distributed constant line (12) at least at one position and an ohmic contact electrode (13,14) contacting the semiconductor conductive layer (15,16) are arranged. According to this invention, characteristics of ICs can be optimized against a variation in elements combined with a circuit comprising the distributed constant line after the manufacture of ICs.

Fig.1

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The present invention relates to a microwave integrated circuit (IC) used for processing a microwave or millimeter wave signal having a very high frequency of several GHz or higher.

Recently, along with the rapid progression of IC techniques, microwave ICs tend to hold an important place in microwave circuits. In such a microwave IC, a circuit having a function of impedance conversion or filtering is constituted by a distributed constant line such as a microship line obtained by adhering a metal thin film on a semiconductor substrate.

In the conventional micorwave IC, it is convenient if characteristics of the distributed constant line can be externally and electrically adjusted after the manufacture of an IC.

For example, in order to obtain a maximum gain in an IC constituting an amplifier, it is necessary to add an impedance matching circuit for impedance-converting a characteristic impedance (50 Ω) of an externally connected microstrip line into a conjugate complex $S_{11}{}^{*}$ of an S parameter $S_{11}$ of an amplification FET. However, FETs suffer from variations in manufacture, and hence, the S parameter also varies. Therefore, a standardized matching circuit cannot realize designed performance. The same also applies to an output matching circuit.

It is an object of the present invention to optimize characteristics of ICs against a variation in elements combined with a circuit comprising the distributed constant line after the manufacture of ICs. Thus, the invention provides a micorwave IC and a method for operating thereof according the claim 1 and claims 5 to 9. A line formed of a Schottky metal is formed as a distributed constant line, and a semiconductor conductive layer contacting the Schottky metal line and an ohmic metal electrode contacting the semiconductor conductive layer are arranged.

In a micorwave IC, a distributed constant line is formed by depositing or plating a metal thin film on a semiconductor substrate, and its film thickness is about 1 to 10 µm. The electrical characteristics of the distributed constant line are mainly determined by the frequency of a signal to be processed, and the width and length of the line itself.

In the present invention, a Schottky diode is formed between a Schottky metal line and a semiconductor conductive layer. If the semiconductor conductive layer is assumed to have an n conductivity type, when a DC potential of the semiconductor conductive layer is lower than that of the line, a forward-biased current flows from the line side toward the semiconductor conductive layer side. Otherwise, no current flows. Therefore, the effective length of the distributed constant line can be changed by a DC potential externally applied to the semiconductor conductive layer through the ohmic metal electrode.

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not to be considered as limiting the present invention.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

## BRIEF DESCRIPTION OF THE DRAWINGS:

Fig. 1 is a plan view showing an embodiment of the present invention; and

Fig. 2 is a plan view showing another embodiment of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Length control of a short (short-circuiting) stub will be explained below with reference to Fig. 1. A Schottky metal line 12 and ohmic metal electrodes 13 and 14 are formed on a semiconductor substrate 11. Semiconductor conductive layers 15 and 18 are formed on a surface portion of the semiconductor substrate 11. The semiconductor conductive layers 15 and 16 are formed such that their one-end portions contact the Schottky metal line 12 and their other-end portions contact the ohmic metal electrodes 13 and 14. Schottky diodes are formed at regions 17 and 18 where the Schottky metal line 12 overlap the semiconductor conductive layers 15 and 16, and ohmic contacts are formed at regions 19 and 20 where the ohmic metal electrodes 13 and 14 overlap the semiconductor conductive layers 15 and 16. Note that the ohmic metal electrodes 13 and 14 respectively comprise lead portions 13A and 14A and pad portions 13B and 14B.

In this embodiment, GaAs is used as a material of the semiconductor substrate 11. The semiconductor conductive layers 15 and 16 have an n conductivity type by doping Si ions in the substrate 11. The Schottky metal line 12 has a three-layered structure of Ti/Pt/Au, and the ohmic metal electrodes 13 and 14 has a two-layered structure of AuGe/Ni.

Since the conductive layers 15 and 16 have the n conductivity type, a short-circuit portion of a short stub constituted by the Schottky metal line 12 changes in a case (1) wherein a DC potential lower than that of the Schottky metal line 12 is applied to the pad portion 14B and in a case (2) wherein the DC potential of the pad portion 14B is set to be higher than that of the Schottky metal line 12, and instead, a DC potential lower than that of the Schottky metal line 12 is applied to the pad portion 13B. In the case (1), an effective length as the short stub is decreased by $\ell$ as compared to that in the case (2).

More specifically, in the case (1), a short stub extending from the region 18 to the ohmic metal electrode 14 via the semiconductor conductive layer 16 is formed. In the case (2), a short stub extending from the region 17 to the ohmic metal electrode 13 via the semiconductor conductive layer 15 is formed.

Therefore, a line of a portion which will require adjustment later is formed by the Schottky metal line beforehand, and is connected to the ohmic metal electrode through the semiconductor conductive layer. Thus, the characteristics of the line can be externally adjusted by increasing/decreasing a DC potential applied to the semiconductor conductive layer through the ohmic metal electrode after the manufacture of an IC.

When DC potentials to be applied to the pad portions 13B and 14B are set to be higher than that of the Schottky metal line 12, an open stub can be formed.

In the above embodiment, when three or more sets of the semiconductor conductive layers 15 and 16 and the ohmic metal electrodes 13 and 14 are formed, the length of the short stub can be changed in three or more steps.

Note that DC components and high-frequency signal components can be discriminated from each other, and a DC potential set to adjust the length of the line does not adversely influence signals.

Materials used in the above embodiment are merely examples, and the present invention is no limited to this.

For example, as a material of the substrate, InP may be employed. Ions to be doped to form an n-type semiconductor conductive layer in a GaAs substrate include Se, Sn, Te, and the like in addition to Si.

Fig. 2 is a plan view showing another embodiment of the present invention. In this embodiment, a semiconductor conductive layer 23 is formed to cross a Schottky metal line 22 formed on a semiconductor substrate 21 at two positions, and is connected to an ohmic metal electrode 24. In this case, Schottky diodes are also formed on regions 25 and 26. Thus, the length of a line can be adjusted by setting a higher or lower DC potential to be applied from the ohmic metal electrode 24 to the semiconductor conductive layer 23 than that of the Schottky metal line 22.

More specifically, when the DC potential to be applied to the ohmic metal electrode 24 is set to be lower than that of the Schottky metal line 22, the Schottky metal line 22 and the semiconductor conductive layer 23 are electrically connected to each other on both the regions 25 and 26. For this reason, a new line for effectively short-circuiting the regions 25 and 26 is formed.

From the invention thus described, it will be obvious that the invention may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

## Claims

1. A micorwave integrated circuit comprising a distributed constant line (12;22) formed of a metal thin film formed on a semiconductor substrate (11; 12), characterized in that said distributed constant line (12;22) is partially or entirely formed of a Schottky metal, and said microwave integrated circuit comprises a semiconductor conductive layer (15,16;23) contacting said Schottky metal line (12) and an ohmic metal electrode (13,14;24) contacting said semiconductor conductive layer (15,16;23).

2. A micorwave integrated circuit according to claim 1, characterized in that said semiconductor conductive layer (15,16) contacting said Schottky metal line (12) is formed on stub of said Schottky metal line (12).

3. A micorwave integrated circuit according to claim 1 or 2, characterized in that least at two pairs of semiconductor conductive layers (15,16) contacting said Schottky metal line (12) and ohmic metal electrodes (13,14) contacting said semiconductor conductive layers are formed.

4. A microwave integrated circuit according to claim 1, characterized in that one semiconductor conductive layer (23) contacts said Schottky metal line (22) at least at two positions (25,26).

5. A method of controlling characteristics of a microwave integrated circuit of any one of claims 1 to 4, characterized in that a DC potential to be applied to an ohmic metal electrode (13,149 is adjusted to switch a conductive/non-conductive state of a Schottky junction portion (17,18;25,26) defined by a Schottky metal line (12;22) and a semiconductor conductive layer (15,16;23).

6. A method of controlling characteristics of a microwave integrated circuit of any of claims 1 to 4, characterized in that a DC potential to be applied

to ohmic metal electrode (13,14;24) is set to be lower than a DC potential of a Schottky metal line (12;22) to render a Schottky junction portion (17,18;25,26) defined by the Schottky metal line (12;22) and a semiconductor conductive layer (15,16;23) conductive, and the DC potential to be applied to the ohmic metal electrode (13,14;24) is set to be higher than the DC potential of the Schottky metal line (12;22) to render the Schottky junction portion (17,18;25,26) non-conductive.

7. A method of controlling characteristics of a micorwave integrated circuit of claim 3, characterized in that a DC potential to be applied to some ohmic metal electrodes (13) is set to be lower than a DC potential of a Schottky metal line (12), a DC potential to be applied to other ohmic contact electrodes (14) is set to be higher than the DC potential of the Schottky metal line (12), and said some ohmic metal electrodes (13,14) are appropriately selected to adjust a length of a short stub (12).

8. A method of controlling characteristics of a microwave integrated circuit of claim 2 or 3, characterized in that a DC potential to be applied to the ohmic metal electrode (13,14) is set to be higher than a DC potential of a Schottky metal line (12), and DC potential to be applied to at least one ohmic metal electrode (f.i. 14) is set to be lower than the DC potential of the Schottky metal line (12) to switch an open stub to a short stub.

9. A method of controlling characteristics of a microwave integrated circuit of claim 3, characterized in that a DC potential to be applied to an ohmic metal electrode (13,14;23) is set to be lower or higher than a DC potential of a Schottky metal line (12;22) to adjust a length of a distributed constant line including the Schottky metal line (12;22).

Fig.1

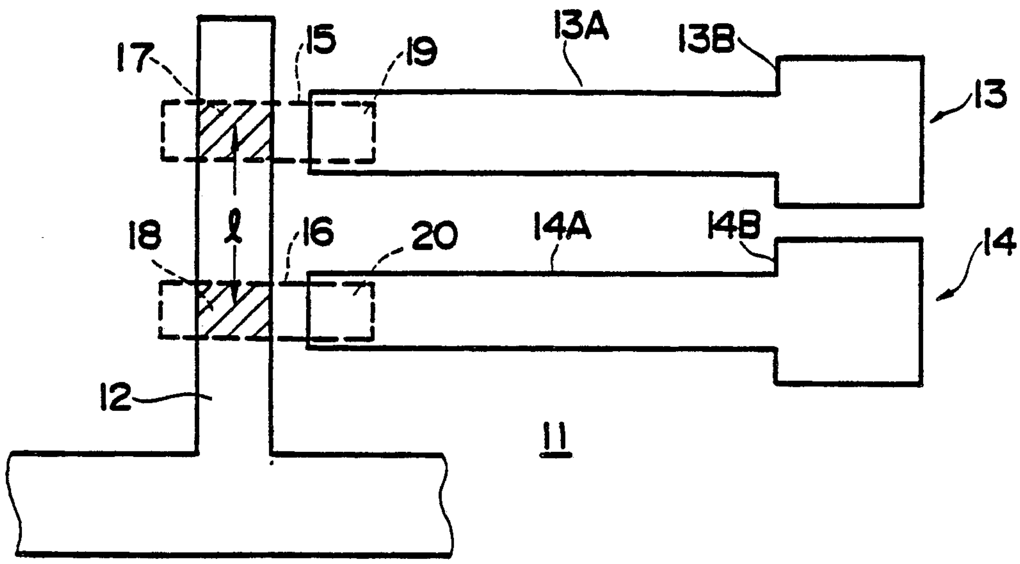


Fig.2