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# C—2—4 High Performance Ni-Pd/GaAs Schottky Barrier Diodes Made by a New Technique

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Introduction : Electroplating is an attractive technique to make Schottky barrier on semiconductor materials only at the required place using a simple and less-expensive apparatus. Electroplated Schottky barrier on GaAs, however, has not been practical because it is contaminated and less-reliable. We have conquered these problems by developing a new technique to electroplate a Ni-Pd binary alloy on GaAs and thereby realized practical high quality GaAs Schottky barrier diodes(1).

Diode Fabrication : The GaAs Schottky barrier diodes have planar structures and are fabricated from epitaxial N on $N^+$ GaAs wafers. After patterning the CVD $SiO_2$ film on GaAs, GaAs is slightly etched and then successively electroplated Ni-Pd for the barrier metal and Au for the contact metal at the oxide-removed places. The Ni-Pd alloy has a composition of 58.5 atm.% Ni and 41.5 atm.% Pd by X-ray analysis. As the total thickness of electroplated metals is almost the same as the thickness of the $SiO_2$ film, no overlay causing stray capacitance is formed. The back surface of the wafers is metallized with Ni-Au-Ge. Schottky diodes have available areas ranging from 8 μm to 100 μm in diameter depending on use.

Diode Characteristics : The Ni-Pd/GaAs Schottky barrier has 1.05 for the ideality factor and 0.92 V for the barrier height. Fig. 1 shows the mean time to failure (MTTF) versus the reciprocal of absolute temperature (1/T) for the (Au)/Ni-Pd/GaAs Schottky barrier. By extraporating Arrhenius plots, MTTF of $7.5 \times 10^7$ hours is deduced at 60 °C, which is three order magnitude longer than the conventional (Au)/Ni/GaAs Schottky barrier(2). In order to prove the high reliability of the (Au)/Ni-Pd/GaAs Schottky barrier over the (Au)/Ni/GaAs Schottky barrier, temperature stability of these Schottky barriers is investigated using Auger Electron Spectroscopy in Fig. 2. After heat-treatment at 300 °C for 10 minutes, no conclusive change of the indepth profile is observed for the (Au)/Ni-Pd/GaAs Schottky barrier but notable interdiffusion of Ni with GaAs occurs for the (Au)/Ni/GaAs Schottky barrier. Notable improvement of breakdown voltage by Ni-Pd/GaAs Schottky barrier is shown in Fig. 3, where measured breakdown voltages are compared with theory. If the curvature due to the slight etching before electroplating is considered, coincidence between the measurement and the theory will be much better. As overlay causing the undesirable stray capacitance is not formed by this electroplating technique, it is possible to remarkably increase cutoff frequency, for instance cutoff frequency of 2000 GHz is reproducibly obtained by mixer diodes fabricated by this technique. Process utility is investigated in Fig. 4 regarding distribution of breakdown voltage of switching diodes. The small deviation for the Ni-Pd/GaAs Schottky barrier shows the excellent stability and reproducibility of the process.

<u>Application</u> : As an example applying Ni-Pd/GaAs Schottky barrier diodes to practical microwave devices, Fig. 5 shows the noise characteristics and the conversion loss of a mixer performance system in SHF band. System noise figure as low as 4.3 dB and conversion loss as low as 3.0 dB are obtained over 200 MHz, where the noise figure of the IF amplifier is 1.3 dB. This value is satisfactory enough for a practical mixer operating in SHF band.

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(1) H. Kondo and A. Nara, Papers of Technical Group on Electron Devices, IECE Japan, ED-76-89 (1977-01)

(2) M. Ida and Y. Sato, Elec. Comm. Labs. Tech. J., <u>20</u> (8), 1747 (1971)

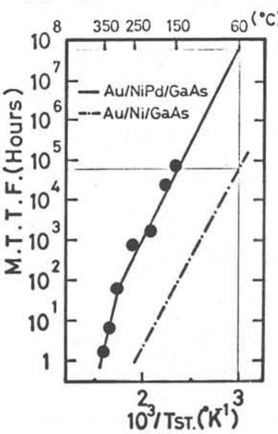


Fig.1

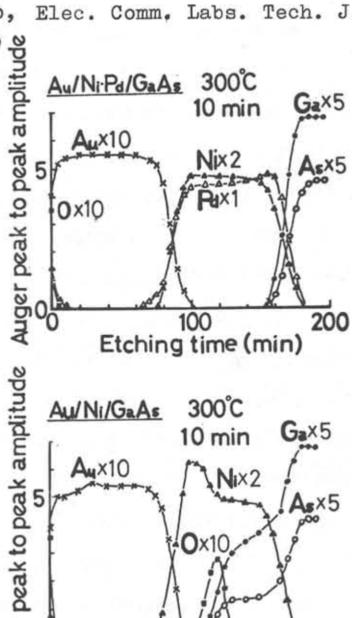


Fig. 2

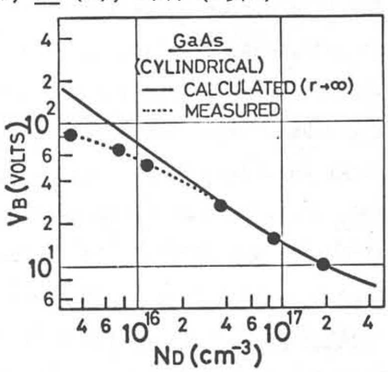


Fig.3

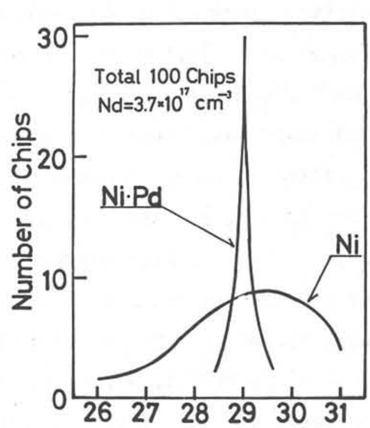


Fig.4

Fig.5

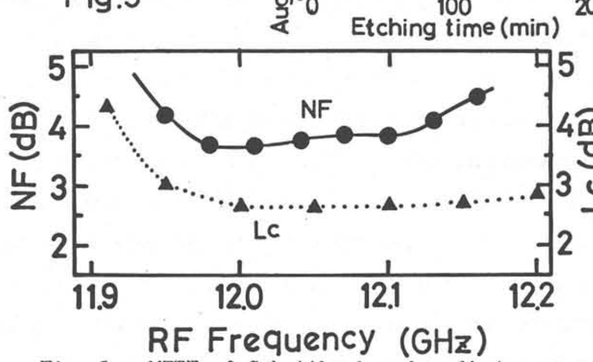


Fig. 1 : MTTF of Schottky barrier diodes as a function of 1/T
Fig. 2 : Analysis of indepth profiles of Schottky barrier diodes using AES
Fig. 3 : Breakdown voltage as a function of carrier concentration
Fig. 4 : Distribution of breakdown voltage
Fig. 5 : Mixer characteristics in SHF band