A possible mechanism for the different dependence on In composition between the two solutions is based on the role of HNO_3. Nitric acid concentrations below 2M exhibit little oxidising power [8]. With $[HNO_3] = 5.0M$ in the 1:1:1 and 3:2:1 solutions, one expects aqua-regia-like behaviour, with formation of Cl_2 and ClO_2 as additional oxidants that appear especially effective for promoting dissolution of higher-In-fraction materials. The 4:1:1 solution, with only 2.5M HNO_3, produces lower overall rates and shows less dependence on In fraction.

We have employed the 1:1:1 $HCl/HNO_3/H_2O_2$ solution for modulator fabrication because the rate was the overriding concern and precise depth control is not needed for this simple mesa-isolation application. However, other applications might require an etchant with less group-III dependence for easier control of etch-depth against time.

In summary, we have developed a suite of etching processes suitable for fabricating optoelectronic devices in the InGaAs/InAlAs materials system. Smooth, near-vertical equirate etching of periodic InGaAs/InAlAs multilayer structures, such as mirror stacks, is achieved with Cl_2/Ar RIBE at elevated temperatures with real-time reflectance monitoring to permit precise depth control (±8nm). Two wet chemistries, $HCL/H_2O_2/H_2O$ and $HCL/HNO_3/H_2O_2$, have been developed for mesa isolation applications.

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High breakdown voltage Schottky barrier diode using p^+-polycrystalline silicon diffused guard ring

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Indexing terms: Schottky diodes, Polysilicon

A new Schottky diode structure which uses the p^+-polycrystalline silicon (polysilicon) diffused guard ring is proposed. The diode gives nearly ideal J-V characteristics with a high reverse breakdown voltage (148V) and a low reverse leakage current density (8.4μA/cm²).

Introduction: The Schottky diode, being a majority carrier device, finds applications in high frequency areas. However, it cannot be applied to high power areas due to its low breakdown voltage which is caused by the edge effect [1]. Hence, the guard-ring structure [2, 3] and the overlap-metal structure [3–5] were proposed to eliminate the premature edge breakdown to improve the breakdown voltage. Recently, the polyemitter p^+-n diode has been intensely investigated due to its low leakage, high breakdown voltage, fast response and high current gain, when it is applied to the bipolar transistor [6]. In this Letter, we use the polyemitter p^+-n to form the guard ring of the Schottky diode. This has the advantages of the low leakage current and high reverse breakdown voltage of poly-emitter diodes but maintains the advantages of Schottky diodes. The fabricated device was found to demonstrate the above feature.

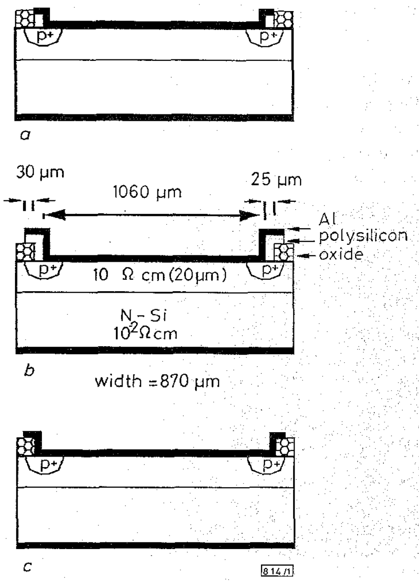

Fig. 1 *Cross-sectional schematic diagram of proposed polysilicon emitter guard-ring junction Schottky diode*

The structure of the diode is shown in Fig. 1*a*. The dimensions and the doping of the fabricated devices are also shown in the Figure. The guard ring of the diode was formed by first defining a guard-ring pattern on the field oxide then depositing a polysilicon

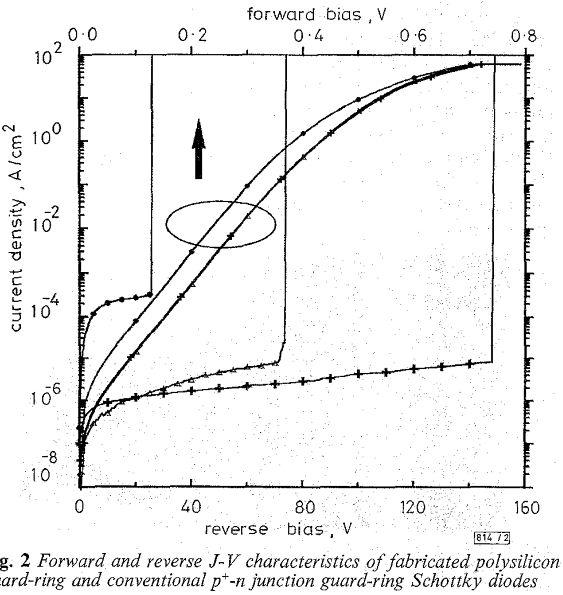

Fig. 2 *Forward and reverse J-V characteristics of fabricated polysilicon guard-ring and conventional p^+-n junction guard-ring Schottky diodes*

—△— gr diode without polysilicon-overlap
—+— gr diode with polysilicon-overlap
—●— conventional diode with metal-overlap

film of 3000Å, which was BF_2^+-implanted with a dosage of 10^{16}cm^2. The device was then furnace-diffused, with the polysilicon as the diffusion source. Al metal film was then evaporated and defined to be the electrode of the Schottky diode. The diode can also be fabricated with the polysilicon overlap as a field plate as shown in Fig. 1*b*. For comparison, the conventional BF_2^+-diffused guard-ring structure Schottky diode with metal overlap was also fabricated.

Fig. 2 shows the measured J-V characteristics of the three types of diode. The polysilicon guard-ring diode without metal overlap showed near-ideal forward characteristics with an ideality factor n of 1.07 for seven decades. The polysilicon guard-ring diode with polysilicon-overlap had a breakdown voltage of 73V and breakdown current of 24.2μA/cm^2. The extracted barrier height was 0.76eV. The breakdown voltage of the polysilicon-overlap diode reached 148V with a reverse leakage current of 8.4μA/cm^2. For the conventional p^+-n diffused guard-ring metal-overlap diode, the reverse breakdown voltage was ~25V with a breakdown current of 332μA/cm^2 and extracted barrier height of 0.73eV. Fig. 3 shows the statistical plots of the breakdown voltages for the three types of diode for each of 30 diodes. The polysilicon guard-ring diodes without polysilicon overlap had better breakdown statistics than that of the conventional p^+-n guard-ring diodes and the polysilicon diodes with polysilicon-overlap even had better breakdown statistics.

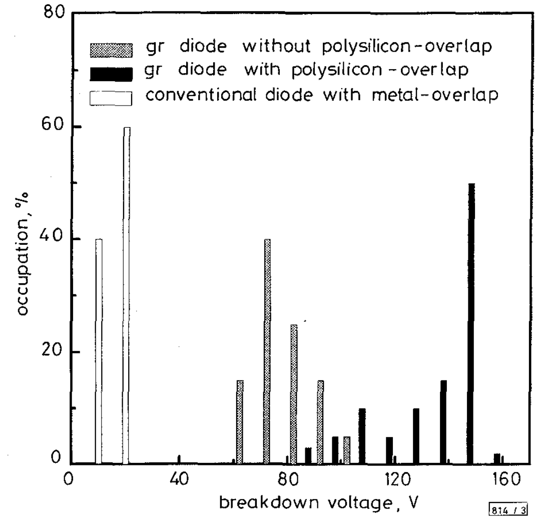

Fig. 3 *Statistical plots of reverse breakdown voltages of polysilicon guard-ring diodes and conventional p^+-n junction guard-ring diode*

Conclusions: The breakdown voltage of the Schottky diode of the guard-ring structure can be increased by fabricating the guard ring with a heavily-doped polysilicon film to form a polysilicon emitter guard-ring junction.

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Low-frequency dispersion characteristics of GaN HFETs

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Indexing terms: Electron traps, Field effect transistors, Gallium nitride

The low-frequency transconductance and output resistance of AlN/GaN HFETs have been examined as functions of temperature. Dispersive characteristics were found which are indicative of trapping activity in the GaN channel layer. Traps with an activation energy near 1eV were evident.

Introduction: Wide-bandgap semiconductors are of interest for high-temperature and high-power applications from DC into the microwave range. This interest stems primarily from the lower thermal generation rates and higher breakdown fields inherent in wide-bandgap materials. In addition, GaN-based devices can also be designed with heterojunctions for improved performance. The DC and microwave characteristics of GaN-based HFETs have been recently reported [1 – 3].

Device fabrication and characteristics: The GaN epitaxial layers used in this study were undoped and grown on basal-plane sapphire substrates by OMVPE [4]. The device cross-section is shown in Fig. 1. C/V measurements indicated that most of the carriers in the active channel are located near the GaN/AlN interface. Variable-temperature Hall-effect measurements yielded a constant mobility and sheet carrier concentration over the temperature range from 10 to 120K. These results are consistent with the existence of a 2-DEG at the GaN/AlN interface [3].

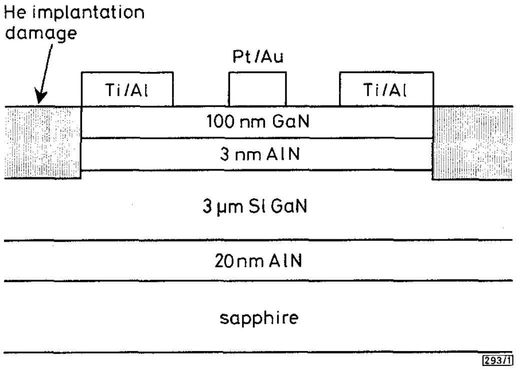

Fig. 1 *HFET cross-section*

The devices were fabricated with a source-drain spacing of 5μm and a gate length of 1.0μm. The total gate width is 150μm. Alloyed Ti/Al was used to form the source and drain ohmic contacts. The gate metallisation was Pt/Au. The devices were isolated using He-implantation-induced damage. The DC drain characteristics are shown in Fig. 2. The HFETs have a pinch-off voltage of 6V and a maximum g_m of 45mS/mm. The measured f_T and f_{max} values were 8 and 22GHz, respectively.

Frequency-dispersion measurements: The use of transconductance and output resistance dispersion measurements to examine trapping characteristics in FETs was first reported by Gregory *et al.* [5]. In the GaN HFETs examined here, the most prominent dispersive mechanisms had conveniently measured transition frequencies only at elevated temperatures. This implies the existence of