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Low frequency noise in p'-GaAs with non-alloyed contacts

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Measurements of 1/f noise were performed including and excluding the influence of the contacts formed by metallic aluminum layers (MBE) deposited on the p'-type GaAs (MBE). The results show that the MBE process can produce non-alloyed ohmic contact free of noise. The 1/f noise of bulk p'-GaAs is characterized by $\alpha_{\text{MBE}} = 5 \times 10^{-4}$.

Introduction: 1/f noise is notorious for its ubiquity in electronic devices and electrode contacts. Experimental studies on 1/f noise in semiconductor GaAs have focused on n-type GaAs. There are only two publications about 1/f noise in p-type GaAs [1, 2]. The two values of a reported in these papers differed by two orders of magnitude. Therefore, we further investigated the 1/f noise in p-type GaAs.

We used a new procedure for making contacts. We grew an epitaxial layer of p'-type GaAs and immediately deposited a 0.2-μm thick aluminum layer on it in the MBE chamber at +20 °C (sample W214) and ~25 °C (sample W249 and 243), respectively [3]. Noise-free contacts of low resistance were obtained.

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In four-point measurement, the contact noise of drivers can be removed from the results by selecting \( R_1 >> R_2 \). The linear dependence of the resistance on the contacts, and the contact noise in two-point measurements, are the same for a chosen pair of terminals. Clearly, the contacts on the samples W243 and W249 are free of noise. Another proof for this conclusion is that for W249 with the BSHB structure, the ratio of the longitudinal noise \( S_L \) to the transverse noise \( S_T \) is -0.1 in accordance with calculations given in [5], where the contacts were considered ideal.

As for sample W249 with TLM structure, the model for current through the sample is also presented in Fig. 3a. It is proved by the linear dependence of resistance on \( L \), where in this case we define \( L \) as the centre-to-centre distance between the two contacts. The contact resistance is so high that the current only passes through the GaAs layer. The process of contacting at the high temperature of +25°C influences the quality of the parts of the sample located directly under the contact, which is the source of the high 1/f noise shown in Fig. 3c. We cannot be sure that this process does not create traps in the sample; even if we do not observe the 1/f noise spectrum. Maybe the 1/f noise is so high that it dominates a possible g-r noise spectrum.

Both lattice scattering and impurity scattering contribute to the measured mobility \( \mu_{\text{meas}} \) and to its fluctuations characterised by \( \sigma_{\mu_{\text{meas}}} \). The relationship between \( \alpha_{\mu_{\text{meas}}} \) and \( \mu_{\text{meas}} \) is given by:

\[
\alpha_{\mu_{\text{meas}}} = \left( \frac{\mu_{\text{meas}}}{\mu_{\text{df}}} \right)^2 \times \alpha_{\mu_{\text{df}}}
\]

as explained in [4]. The results for \( \alpha_{\mu_{\text{meas}}} \) are presented in Fig. 4, where we use \( \mu_{\text{df}} = 400 \text{cm}^2/\text{V}\text{s} \) and \( \mu_{\text{meas}} \) is 120 cm^2/Vs for our samples.

**Fig. 2** Noise power density against frequency in two-point measurement

- \( \Delta W249 \)
- \( \square W243 \) including thermal noise and noise of preamplifier
- \( \circ \) excluding thermal noise and noise of preamplifier

**Fig. 3** Sample W214 with TLM structure

- \( \Delta W249 \)
- \( \square W243 \)
- \( \circ \) Noise power density against length L

**References**