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FIELD EMISSION FLICKER NOISE FROM SMALL REGIONS OF GERMANIUM EMITTERS WITH ATOMICALLY CLEAN SURFACE

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Abstract - An attempt was made to study electron states on evaporated and annealed clean (OII) plane of Germanium by the field-emission current-fluctuation method.

I - INTRODUCTION

Spectral characteristics of low-frequency field emission current fluctuations from semiconductors contain an information about temporal and statistic parameters of electron and adsorption-migration processes on surface /I/. Moreover for receiving reliable quantitative relationships it is necessary to carry out researches on surfaces with definite structure and electron characteristics.
In the present paper there are given the research results of low-frequency field emission current noises from closely packed (OII) Ge plane with atomically clean surface. The choice of (OII) plane is also connected with the knowledge of its parameters by other methods /2/. Moreover it was important to try determining minimal dimensions of the region where I/f noise is still observed /3/.

II - EXPERIMENTAL

The experiments were carried out in the probe-hole all glass field emission microscope with a screening suppressor Faraday collector in vacuum $3 \cdot 10^{-9}$ Pa. The probe-hole is 2 mm in diameter and lets to probe emitter surface area not more than 200 Å. The emitters were prepared from Ga-doped p-type Ge single crystals with resistivity 3 Ohm . cm and were cleaned by dc field desorption till getting a symmetrical field emission pattern.
A block diagram of the measurement is shown in Fig.I. Measurements were carried out by a direct starting in digital code and the following analysis of discrete samplings of the initial stochastic process with the help of micro-computer. Noise signal analysis was carried out in the real time scale with the use of multi-processing system excluding side digital filtering displays. The used algorithm of the fast Fourier transformation let to do without multiplying the taken sampling by a distinguishing (prominent) function.

III.- RESULTS AND SHORT DISCUSSION

Fig.2 shows the spectra of fluctuations taken at emission current $I = IO^{-IO}A$ from the plane centre (OII) of atomically clean annealed (curve I) and evaporated (curve 2) Ge surfaces. It is seen from the figure that the main component of field emission current fluctuation at frequency band lower than IO Hz is flicker noise, moreover the emitter surface state doesn't influence on the fluctuation spectra form within the quasistationarity. Besides for the spectral density function S the empirical Hooge relation is correct /4/:

$$S = \alpha \cdot I^2/N \cdot f$$

where: $\alpha = 2 \cdot IO^3$, f - is frequency, N - the number of electron states. The received data are well correlating with the results received by LEED method (about the existence of two types of surface structures on (OII) Ge plane at different temperatures /5/).
I/f noise appeared to be more stationary (in level) on a thermo - dynamically stable annealed surface. In these conditions electron state density n calculated according the statistic surface model /I/, (connecting electron surface characteristics and current fluctuation parameters, when $D(I) = I^2/2N$, where D - is dispersion of current fluctuation) on (OII) Ge plane appeared to be equal:

$$n = (8 \pm I) \cdot IO^{I3}\ cm^{-2}.$$

On the metastable evaporated surface the number N is rather critical to its state and at safe emission pattern and unchanged current-voltage characteristics n for (OII) Ge plane is changing within $(0,8 - IO,0) \cdot IO^{I4}\ cm^{-2}$.
It is observed that electron state density changes from the plane centre to its outlying areas.

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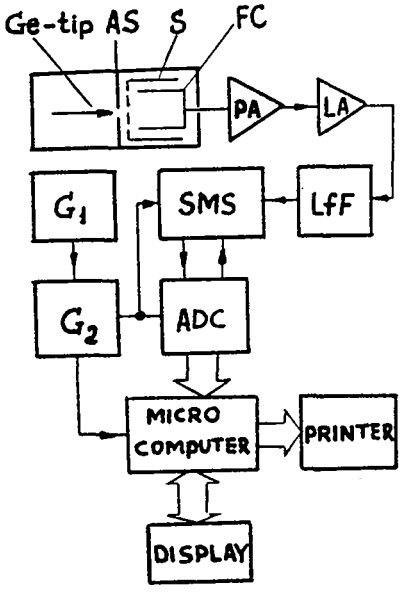

Fig.I. Block-diagram of measurement. AS: anode-screen; FC: Faraday collector, S: suppressor, PA: preamplifier, LA: linear amplifier, LfF: low frequency filter, SMS: sampling-memory scheme, ADC: analog-digital converter, G_I: master pulse generator, G_2: time marker generator.

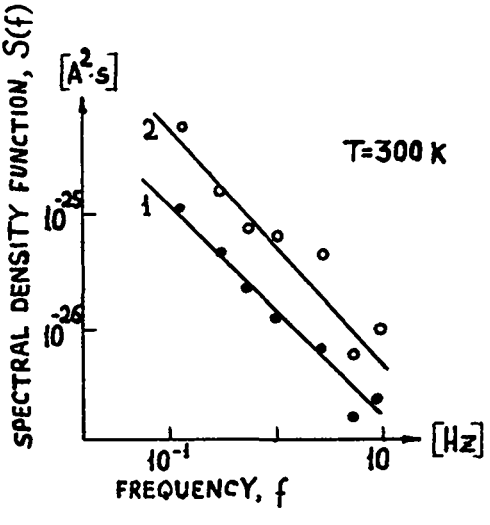

Fig.2. Power spectral density functions of field emission current fluctuations from annealed (curve I) and evaporated (curve 2) Ge (OII) clean crystal plane.