SHOTTKY FIELD EFFECT TRANSISTOR WITH SUPERHIGH SPEED

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Field transistors with controlling Shottky type junctions of vertical structures on the basis of SiC/Si material with various length of channels have been investigated.

It is shown, that increase of fast action in the wide band of temperature (up to 700 °C) is reached under extremely low lengths of the channel (<100 nm) and thermocorrelated supply voltage.

Field effect transistors (FET) with controlling Shottky type junctions have some advantages in comparison with bipolar and MOS-transistors, related with possibility to use more short channels and providing for higher speed [1].

One of major limitations for minimal length of ShFET is connected with effect of modulation of channel's length, which leads to triode character of V-A characteristics [2].

In order to eliminate the modulation of the channel, special constructions of normally closed ShFET with vertical channels of *n*- and *p*-type, named as transistors with static induction (SIT) were developed [3], where the channel was the area of space charge (ASC) for whole band of working voltage at the transistor exit leads. Control of the drain current I_d is carried out through changing of the height of potential barrier of source-channel, occurred as a result of diverse level of alloying of source and drains areas (fig. 1).

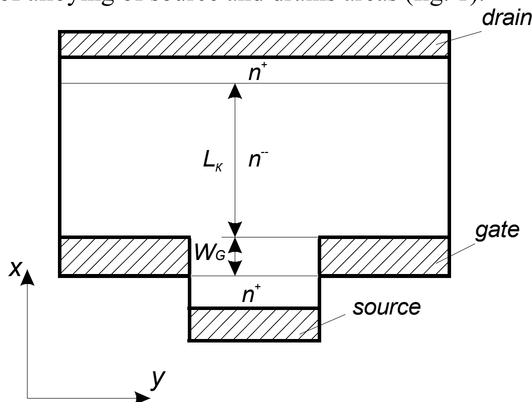

Fig. 1. Structure of n-channel SIT with Shottky barrier.

Height of the potential barrier is determined by a voltage gate-source U_s and lightly depends on voltage of drain-source U_d due to low thickness of channel by source.

Major factors restricting a wide use of SIT as submicron elements of superhigh speed integral circuits, are:

- triode character of V-A characteristics of SIT, conditioned by dependence of height of potential barrier in the channel from voltage gate-source and drain-source, also by modulation of ASCs width in the channel by voltage U_d;
- presence of passive areas of spatial charge between drain-source contacts and the gate.

Using of silicon carbide as a base material, which exceeds silicon on major parameters [4]: -wide bandgap, permitted working temperatures, speed of drift of charge carriers ($2{,}5\cdot10^7$cm/s) allows to eliminate those shortcomings [5]. Using of heteroelectronic structures SiC/Si broadens the functional capabilities of the elements and allows technological integration of them with elements of integrated circuits [6].

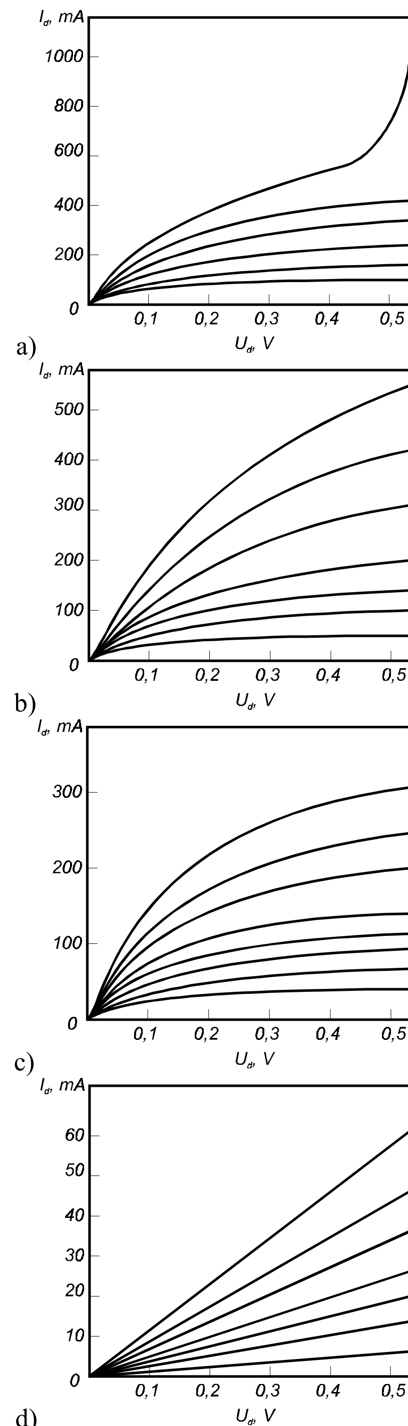

Fig. 2. Volt-ampere characteristics of ShFET with different length of channel

The technology of forming of silicon carbide structures on the silicon doesn't differ in principle from processes of forming of silicon films and is carried out on the typical equipment [7, 8].

Heteroepitaxial layers were grown-up by the method of vapor-phase epitaxy in the open system: diffusion technology in two-zone oven was used. Hydrogen was used as gas-carrier: in first zone the free carbon is associated with hydrogen and is carried to the zone of growth of semiconductor film. The temperature of carbidized pedestal at which hydrocarbons become decomposed and the silicon substrate is carbidized is equal to 1360-1380 °C.

Ohmic contacts for SiC films were formed by method of thermal deposition of nickel by further pulse type thermo-processing by non- coherent IR radiation on the technology described in [9].

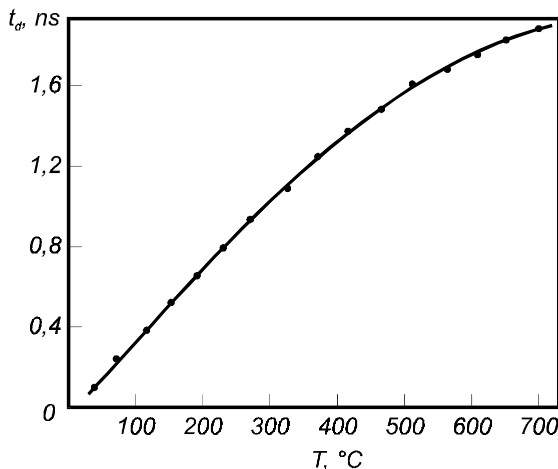

Fig. 3. Dependence of ShFET logic elements switching delay time on the temperature.

Output characteristics of depleted ShFET with space charge limited current (SCLC), made on the basis of silicon carbide with -type channel for values of the channel length *L*=30 nm (fig. 2a), *L*=40 nm (fig. 2b), *L*=100nm (fig. 2c) and L=250 nm (fig. 2d) are given in fig. 2. The results of measures have shown, that on channels length equal to 30-100 nm, V-A characteristics has a pentode but by increase of the channel's length up to 250 nm, these characteristics become near near to linear type ones (fig. 2d). Sharp increase of the drain's current on *L*=30 nm (fig. 2a) is conditioned by the tunnel effect, occurred under minimal length of the channel.

Dependence of time delay of switching of integrated logic element made on the basis of complementary ShFET with SCLC from temperature by voltage source U_s=0,2 V is given in fig. 3. Increase of switching delay is connected to the temperature dependence of the carrier's mobility.

In order to increase fast-response and to widen the temperature band of elements made at the basis of ShFET the thermocorrelated supply have been used. This means, that in the process of functioning of IC, the supply voltage was decreased in proportion to the temperature change of height of potential barrier of source-drain. This makes it possible to curtail the time delay of logic elements switching made on the basis of ShFET down to parts of nanoseconds, i.e. more, than 5 times (fig. 4).

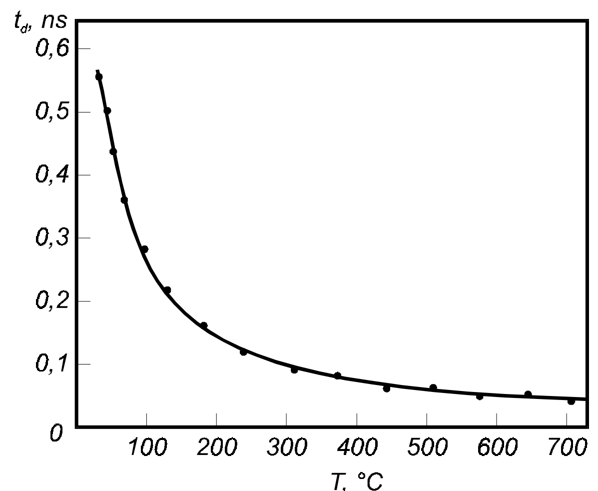

Fig. 4. Dependence of delay time on temperature under thermo correlative supply voltage

As a result, the pentode character of V-A characteristics, the high steepness of transistors, the low values of time delays allow to design super high fast action IC on the basis of field transistors with controlling Shottky type junctions.

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İFRAT YÜKSƏK CƏLDLİYƏ MALİK ŞOTTKİ SAHƏ TRANZİSTORLARI

Müxtəlif uzunluqlu kanallı SiC/Si əsasında vertikal struktura malik idarəedici Şottki keçidli sahə tranzistorları tədqiq edilmişdir.

Göstərilmişdir ki, geniş temperatur diapazonunda (700 °S-yə qədər) cəldliyin artırılması, kanalın ifrat kiçik uzunluqlarında (<100 nm) və termokorrelyasiya olunmuş qida gərginlikləri zamanı əldə edilir.

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ПОЛЕВЫЕ ТРАНЗИСТОРЫ ШОТТКИ СО СВЕРХВЫСОКИМ БЫСТРОДЕЙСТВИЕМ

Исследованы полевые транзисторы с управляющим переходом Шоттки вертикальной структуры на основе SiC/Si с различными длинами каналов. Показано, что повышение быстродействия в широком диапазоне темперпатур (до 70°C) достигается при сверхмалых длинах канала (<100 нм) и термокоррелированном напряжении питания.

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