ростом напряжения смещения спектр РСГУ в диодах второго типа. С увеличением напряжения смещения (т. е. при зондировании более глубоких областей кристалла) доминирующим становится пик E035 и появляется пик E021, расположенный в области низкотемпературного крыла более мелкого пика дивакансии E024.

Из анализа вольт-фарадных характеристик было установлено, что в диодах второго типа происходит образование дефектов на глубинах, существенно превышающих максимальную глубину проникновения альфа-частиц. При оценке глубины учитывался тот факт, что исследуемая структура состоит из 3-х слоев: алюминия (d = 4,5 мкм), кремния p-типа проводимости (d = 12,7 мкм) и кремния n-типа проводимости (d = 32 мкм, глубина проникновения α-частиц в базу n-типа может быть оценена как (24,8 – 17,2) мкм = 7,6 мкм. Эта оценка также подтверждается данными измерений C–V-характеристик. В то же время обратное напряжение >15 В соответствует глубинам >12 мкм.

ЗАКЛЮЧЕНИЕ

Таким образом, обнаруженное на разных глубинах изменение соотнощения между концентрациями основных радиационных дефектов свидетельствует об эффекте дальнодействия при облучении альфа-частицами данной энергии. Этот эффект проявляется прежде всего в структурах с более глубоким залеганием p–n-перехода, т. е. прошедших более длительную стадию диффузионной разгонки фосфора.

ЛИТЕРАТУРА

1. *Тетельбаум Д. И., Баянкин В. Я.* Эффект дальнодействия // Природа. № 4, 2005. С. 9–15.
2. *Алалыкин А. С., Крылов П. Н., Шинкевич М. В.* Эффект дальнодействия в полупроводниках // Вестн. Удмуртского ун-та. 2005. № 4. С. 141–152.

SPECIFIC OF MEASUREMENTS AND MAGNETORESISTANCE DATA ANALYSIS IN PULSED MAGNETIC FIELDS

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1. INTRODUCTION

Investigations of condensed matter properties in high magnetic fields are of great importance as they give information on the behavior of materials put in extremal condictions, and thus, can verify prospective theoretical models which are often formulated with reference to limit cases or make predictions for the later [1, 2]. Such investigations, nevertheless, are very difficult to carry out due to various specific problems which require solutions in every particular case: pulsed magnetic fields often cause effects related to experimental stuff rather than to a studied system. These effects can overwhelm the responses which reveal phenomena taking place in the sample under study. In this paper as an example of high pulsed magnetic fields magnetoresistance measurements and data analysis we present results obtained on SnO_2 nanogranular thin films. The samples fabrication procedure is described elsewhere [3].

Investigations of mesoscopic materials, containing tin-dioxyde structures, are very prospective from both scientific and industrial applicability points of view [4, 5]. High magnetic fields investigations provide possibilities for both verification of charge transport mechanisms and determination of new application possibilities of these structures.

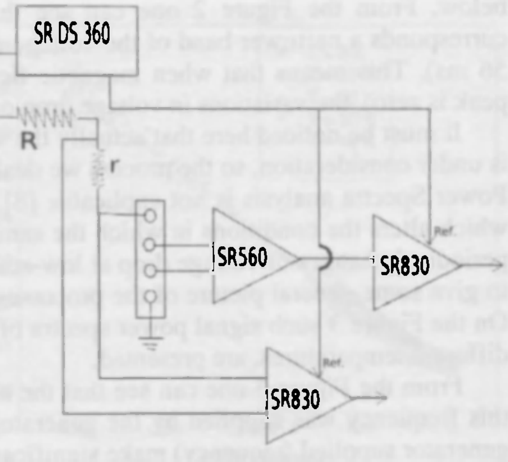

Fig. 1. The principal scheme of the MR-measurements. *r* – is the resistor, used for electric current measurements

2. MAGNETORESISTANCE MEASUREMENTS

The standard lock-in four-probe technique was used in order to measure the resistance of samples as a function of temperature and applied magnetic field. The magnetic field was applied perpendicular to the surface of SnO_2 nanogranular thin film samples. The contacts were placed on the samples surface in linear configuration as shown in Figure 1. The resistance measurements were performed with the help of SR 830 Lock-In Amps. Both the excitation and reference signals were supplied with SR DS 360 Ultra Low Distortion Function Generator. The voltage drop from the inner contacts was amplified with SR 560 Amplifier and then detected by one of the Lock-In Amps. For the temperature control the LakeShore 340 was used. The resistance measurements were performed at the simultaneous application of magnetic field pulse, the duration of each pulse being 600 ms. On Figure 2, the time co-evolution of the measured at $T = 1.8$ K voltage drop on the sample and the applied magnetic field is presented.

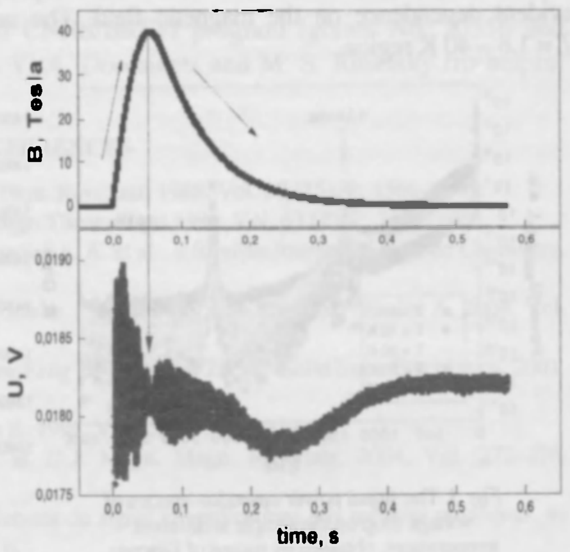

Fig. 2. The co-evolution of measured voltage drop on the sample (lower plot) at $T = 1.8$ K and applied pulsed magnetic field (upper plot) in time

3. RESULTS AND DISCUSSION

Various efficient techniques for electrical measurements in pulsed magnetic fields which implement procedures concerning data acquisition and preprocessing were developed [6, 7].

In contrast, we did not use any specific data acquisition procedures, rather we have performed post-acquisition data analysis presented below. From the Figure 2 one can see that to the maximum in magnetic field pulse corresponds a narrower band of the voltage drop variation (at time moment approximately 56 ms). This means that when magnetic field varies slowly (the derivative *dB/dt* at the peak is zero), the variations in voltage drop on the sample are minimal.

It must be noticed here that actually the voltage drop dependence on the magnetic field is under consideration, so the process we deal with is a nonstationary one, and conventional Power Spectra analysis is not applicable [8]. Magnetic field acts as an external parameter which alters the conditions in which the sample is put. Nevertheless, as we observed clear periodical changes of voltage drop at low-scale time intervals, we expect the power spectra to give some general picture of the processes taking place, although not really correct one. On the Figure 3 such signal power spectra of voltage drop on the sample, corresponding to different temperatures, are presented.

From the Figure 3 one can see that the signals with frequencies 1.33 kHz (signal with this frequency was supplied by the generator) and 2.66 kHz (the second harmonic of the generator supplied frequency) make significant contribution to the total spectrum. As in our measurements the SR 830 Lock-in amps were used, it is natural to associate these peaks with parasitic signals coming from the output of Lock-ins. In order to extract the «message-signal», associated with magnetic field-induced voltage drop change, there was performed frequency domain filtering – the peaks at 1.33 kHz and 2.66 kHz were cut from the power spectra, and after that the Inverse Fourier Transform was performed.

The results of this procedure are presented below. In Figure 4, the experimental data are presented in the form of best mean square calculated curves with corresponding error bars, the last representing standard deviations from the mean values. One can see that after the performed frequency domain filtering the curve reproduces expected behaviour under the application of magnetic field. Moreover, the standard deviations from mean values calculated after filtration are much lower than that corresponding to «non-filtered»-data and have no evident dependence on the magnetic field. The same results were obtained in the whole $T = 1.8 - 40$ K region.

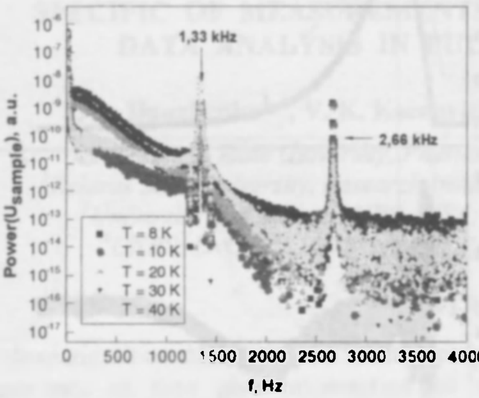

Fig. 3. The signal power «pseudo»-spectra of voltage drop on the sample at different temperatures, obtained by means of Discrete Fourier Transform (sampling interval – $2 \cdot 10^{-5}$ s, lower resolution limit – 1.7 Hz) – see discussion in text

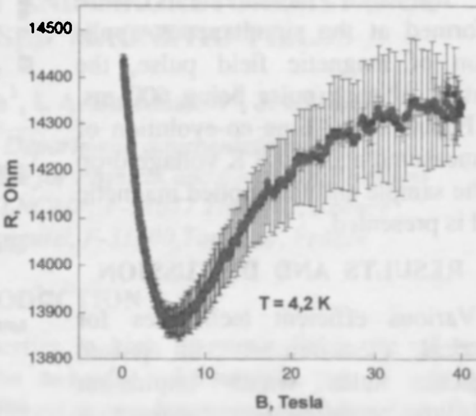

Fig. 4. The magnetic field dependence of resistance, measured on SnO_2 nanogranular thin film at $T = 4.2$ K

In Figure 5, the dependencies of standard deviations (corresponding to the mean values of voltage drop on the sample) on the first derivative of magnetic field on time (*dB/dt*) are presented. It is evident that deviations reach maximal values when the speed of magnetic field change is the highest, the overall dependence being linear. This is just shows that the rapidly changing magnetic flux induces large inductive pick-ups which must be excluded from the message signal.

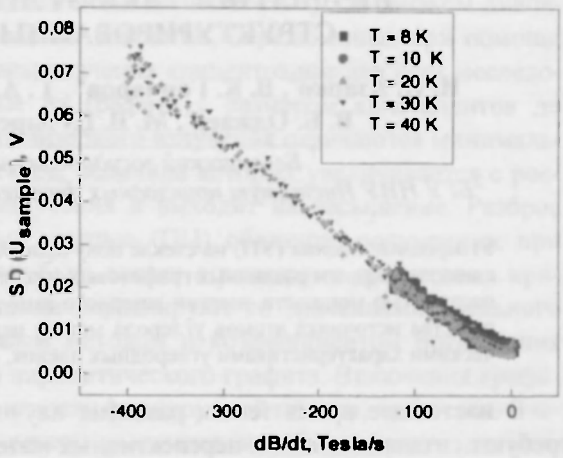

Fig. 5. The dependencies of voltage drop standard deviations on the speed of magnetic field change

4. CONCLUSIONS

In conclusion, we point out that electrical measurements in pulsed magnetic fields are not trivial and require development of special data acquisition and analysis procedures. In our case, the observed at high fields wide dispersion band in measured voltage drop is due to high impact of electromagnetic induction phenomenon, which contributes to the amplitude of the carrier-signal, and thus enhances observed oscillations with frequencies related to that of the signal supplied by the generator. Performed frequency domain filtering enables one to obtain reliable results proper for further physical analysis.

The work was supported by bilateral CNRS/BRFFI program (grants No. 20356 and F07F-013). T. Dauzhenka acknowledges V. A. Dorosinets and M. S. Rusetsky fro helpful discussions.

REFERENCES

1. *Sivan U., Entin-Wohlman O., Imry Y.* // Phys. Rev. Lett. 1988. Vol. 60 (15). P. 1566–1569.
2. *Hikami S., Larkin A. I., Nagaoka Y.* // Progr. Theor. Phys. 1980. Vol. 63 (2). P. 707–710.
3. *Bashmakov I. A., Dorosinets V. A., Ksenevich V. K.* et al. // Russian Journal of Applied Chemistry. 2007. Vol. 80 (2). P. 285–289.
4. *Ksenevich V. K., Dovzhenko T. A., Dorosinets V. A.* et al. // Acta Physica Polonica A. 2008. Vol. 113 (3). P. 1043–1046.
5. *Wang Yu-De, Xing-Hui Wu, Qun Su, Yan-Feng Li, Zhen-Lai Zhou* // Solid State Electronics. 2001. Vol. 45. P. 347–350.
6. *Machel G., Ortenberg M. von* // Physica B. 1995. Vol. 211. P. 355–359.
7. *Kozlova N., Kozlov M., Eckert D.* et al. // J. Magn. Magn. Materials. 2004. Vol. 272–276. P. E1679–E1680.
8. *Max J.* Methodes et techniques de traitement du signal et applications aux mesures physiques. 4e ed.. T. 1 & 2. Masson, Paris. 1985 & 1987. 571 p.