4. CONCLUSIONS

Adequate choice of analysed wavelengths used for CO and O_2 concentration measurement in the layer close to the power boiler's walls is not simple. It requires consideration of many factors coming, both from design of analyser and environment of measurement. Analysis of these factors leads to the following conclusions:

- spectral band above 2,5μm is not considered in the proposed design of analyser because light sources emitting in this band have insufficient power, need cooling systems and are expensive;
- within near infrared band absorption spectra of gases in considered layer overlap, what complicates measurement technique as well as choice of analysed wavelengths;
- extraction of components of interest from gas mixture requires application of special techniques, for example correlation ones;
- considering the commercial availability of light sources and optical components spectral band within 1,55 and 1,60μm is most appropriate for measurement of carbon monoxide concentration and vicinity of 0,76μm for oxygen;
- Optical components of analyser (fibres, filters, and detectors) have to be optimised for the selected wavelengths in to efficiently utilise optical power of the light source.

5. REFERENCES

[1] V. Ebert, J. Wolfrum, "The use of lasers as the basis for combustion equipment control. TOTem 18 - Intelligent Combustion Control", France, 2000.

[2] W. Kordylewski (red.), "Niskoemisyjne techniki spalania w energetyce", Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2000. (in Polish)

[3] I. Manak (red.), "Lazernaja i optiko-elektronnaja technika" Mińsk 1999. (in Russian)

[4] F.K. Tittel, "Advanced infrared gas sensors: development and real-world applications", 2001.

[5] W. Wójcik, I. Manak, S. Przyłucki, A. Kotyra, P. Komada, T. Golec, "Optoelektroniczny analizator do pomiaru koncentracji gazów w warstwie przyściennej kotłów energetycznych", Materiały konferencyjne – VIII Konferencja „Światłowody i ich zastosowania", Białowieża 2002, str. 459-462. (in Polish).

Małgorzata Jakubowska[1], Wojciech Grzesiak[2]

[1] Institute of Electronic Materials Technology, 133. Wólczyńska Str., 01-919 Warszawa, Poland, e-mail: maljakub@sp.itme.edu.pl

[2] Institute of Electron Technology, 39. Zabłocie Str., 30-701 Krakow, Poland, e-mail: zrgrzesi@cyf-kr.edu.pl

HIGH OHMIC MEASUREMENTS OF THICK FILM GLASS LAYER INSULATORS

1. INTRODUCTION

Modern advanced electronic equipment widely uses the multilayers structures. The very important part of the structure is the glass insulators and crossovers. Their physical and electrical properties are becoming very important while high voltage is applied. This paper presents the results of high ohmic measurements of wide range of glass layers which are applied as insulators or crossovers in the multilayers structures.

2. MATERIALS AND TEST PROCEDURE

Four different dielectric pastes has been manufactured for this paper [1-3]. The properties of the dielectric layers such as: chemical composition, temperature expansion coefficients, melting points, firing temperatures are shown in Table 1 and the main electrical properties of the layers are shown in table 2.

Table 1

The physico-chemical properties of the dielectric layers.

Properties of the glass layers	D-421	D-304	c-BN	D-301
Chemical composition	PbO, Al_2O_3, SiO_2, $BaTiO_3$, ZnO, TiO_2	SiO_2, ZnO, BaO, B_2O_3 Al_2O_3, TiO_2, ZrO_2, CdO,	c-BN, Bi_2O_3, B_2O_3 , SiO_2 , CdO, Li_2O	PbO, SiO_2, ZnO, TiO_2, Al_2O_3, MgO, SiO_2, BaO
Temperature expansion coefficient, 10^{-6} $1/^{O}C$	$\alpha_{200\ C}$ = 4.57 $\alpha_{300\ C}$ = 5.02 $\alpha_{-400\ C}$ = 5.52	α_{300}=5.2 α_{400}=5.28 α_{500}=5.40	α_{20-300} = 10.1	α_{300}=8.5
Density of the glass, g/cm^3	3.65	4.25	-	4.78
Melting temperature, ^oC	720^oC	730^oC	-	465^oC
Firing temperature, ^oC	850^oC	850^oC	850^oC	760^oC
Other properties	crystallizing glass, heat insulator	less crystallizing glass than D-421	good thermal conductivity	low temperature of firing

The elaborated pastes were screen printed on 96 % alumina substrates, and fired with the use of standard thick film profile. Single and double layers were deposited on the substrates and when double the layers were fired separately or coffired.

Seven probe resistor pieces were taken into consideration. They were formed on flat ceramic substrate plates and furnished with silver contacting strips along the glass layer's ends. The dimensions of tested resistors are also specified in the Table 3.

Table 2

Electrical properties of the glass layers

Properties	D-421	D-304	c-BN	D-301
Breakdown Voltage, for 60µm thickness, V	> 700 V	> 800 V	> 300 V	> 500 V
Dielectric constant	14	12	30	16

Table 3

Description of the test layers

Test number	Description of the test	Glass layer thickness, μm	No of squares
1	Al_2O_3 + double layer of fired separately dielectric D-421	48	1,28
2	Al_2O_3+ single layer dielectric D-421	30	1,28
3	Al_2O_3 + single layer dielectric D-3041	17	0,76
4	Al_2O_3 + double layer of fired separately dielectric D-3041	38	0,76
5	Al_2O_3 + single layer dielectric based on cubic boron nitride (c-BN)	28	3,06
6	Al_2O_3 + double layer of coffired dielectric D-3014	38	1,26
7	Al_2O_3 + double layer of fired separately dielectric D-3014	42	1,26

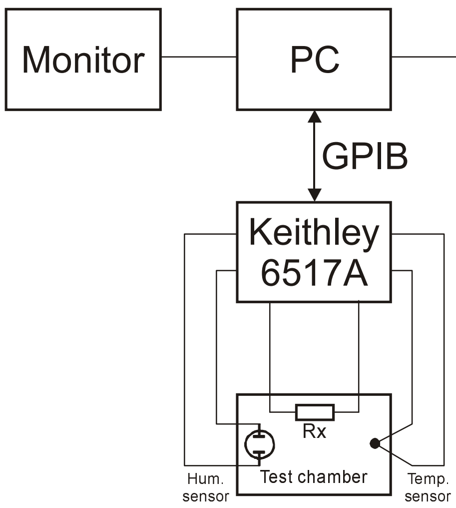


Fig.1 The scheme of the measuring circuit

The measuring circuit consisted of special Keithley 6517A low current electrometer furnished with a precise DC voltage source, a measuring chamber, a PC, monitor and printer (Fig. 1) [4]. The principle of the sole resistance measuring process is based on current value readout, realized after several time constants, beginning from the moment of the DC voltage applying on the probe (Fig. 2).

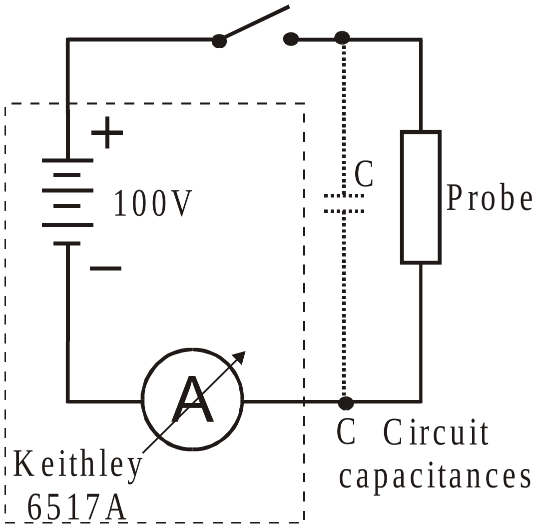


Fig. 2. The principle of the sole resistance measuring process.

3. RESULTS

The basic time constant is represented by measured resistance and capacitances spread over the circuit, especially those parallel to this resistance. After several time constants the capacitive currents become negligible in comparison with the resistive one and the resistive current readout may be done with sufficient accuracy. The resistance value is then calculated from the known 100V applied DC voltage value and the current readout. The measuring results are specified in the Table 1.The current and time plots for tested seven glass insulators are presented on Figures 3 to 9.

Table 4

The measuring results

Probe number	Calculated probe resistance value
1	$2{,}5 \cdot 10^{15} \Omega$
2	$1.0\ 10^{15} \Omega$
3	$1{,}25 \cdot 10^{15} \Omega$
4	$1{,}25 \cdot 10^{15} \Omega$
5	$1{,}43 \cdot 10^{15} \Omega$
6	$3{,}3 \cdot 10^{15} \Omega$
7	$3.5 \cdot 10^{15} \Omega$

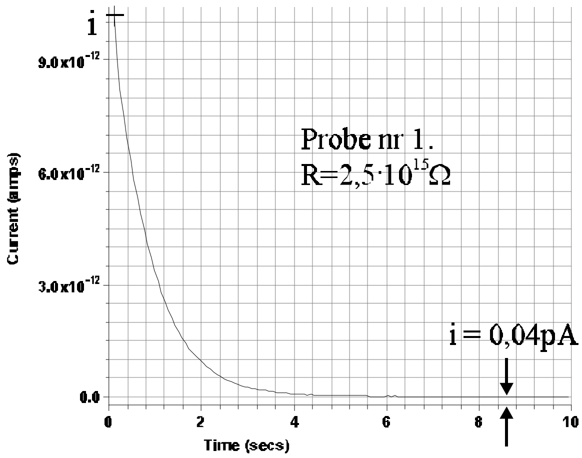


Fig.3 I= i(t) plot for probe nr 1

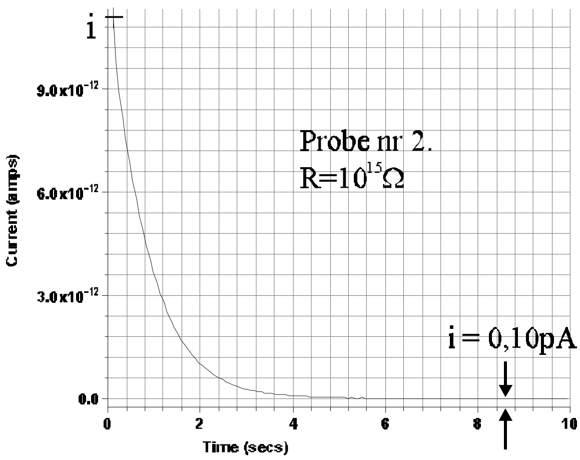


Fig. 4. I= i(t) plot for probe nr 2

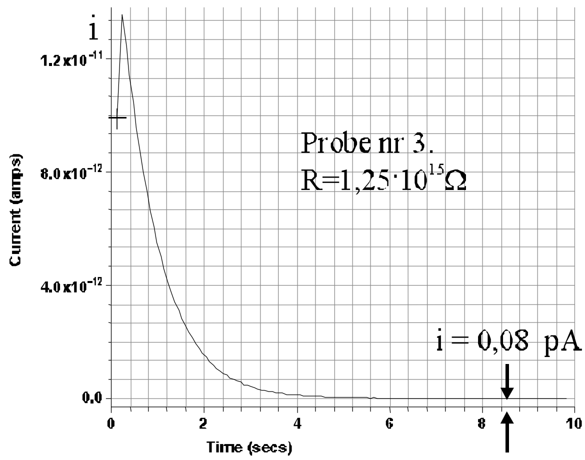


Fig. 5. I= i(t) plot for probe nr 3

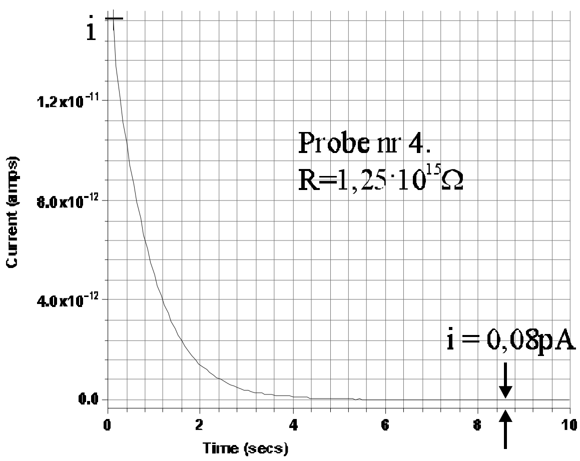


Fig. 6. I= i(t) plot for probe nr 4

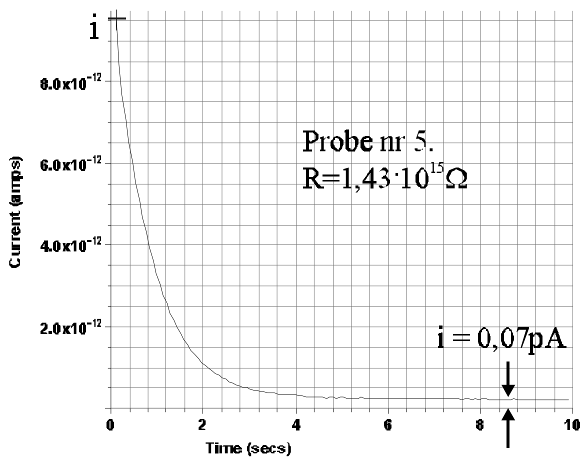


Fig. 7. I= i(t) plot for probe nr 5

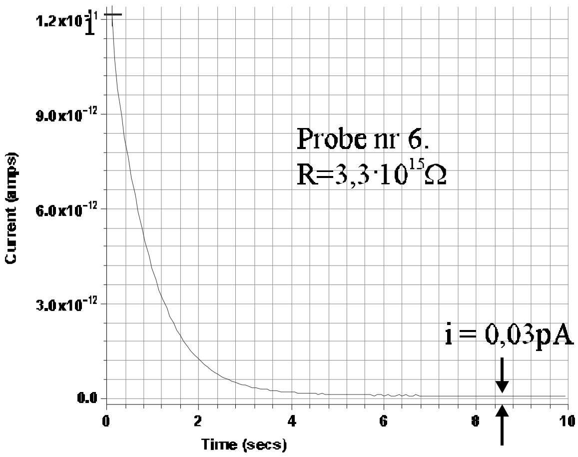
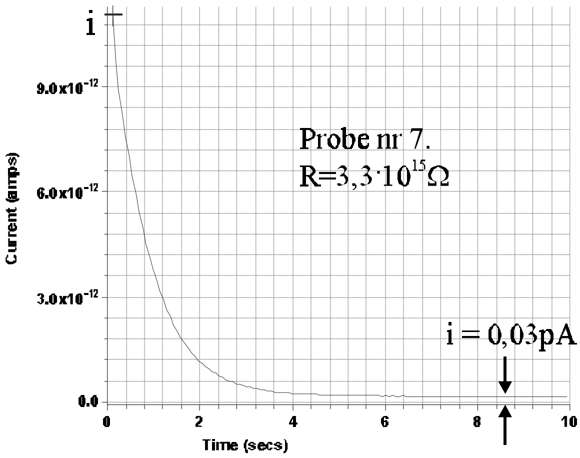


Fig. 8. I= i(t) plot for probe nr 6



......Fig. 9. I= i(t) plot for probe nr 7

4. DISCUSSIONS AND CONCLUSIONS

The examined dielectric layers fulfil the requirements for dielectric or crossover thick film materials. All the presented glass type layers have sufficient insulating properties while used as under– or overglaze films for various applications in resistor manufacturing processes.

The dielectric layers despite from different chemical compositions, different firing temperatures, etc. exhibit similar electrical properties which enables them to be applied in thick film multilayers. According to the dielectric constant and breakdown voltage parameters – the D-304 layer seems to have much better practical properties than the c-BN one. Also very interesting would be resistance measurements of idle substrate plates furnished only with contact strips. The resistance of the substrate evidently acts as parallel to the main one.

REFERENCES

[1] Jakubowska M., Pitt K., Influence. of the contacts and firing process on the properties of thick film resistors on alumina and dielectrics, Journal of Materials Science: Materials in Electronics, no 6, 1995, s.75-78.

[2] Achmatowicz S., Jakubowska M., Zwierkowska E., Szczytko B., Szymański D., Pasta izolacyjna, Patent RP, nr. 162992, in Polish.

[3] Jakubowska M., et al, The New Thick Film Paste Based on Cubic Boron Nitride, Proc. of XXVI Int. Conf. of IMAPS Poland Chapter, Warsaw, 25-27 Sept. 2002, p. 70-74.

[4] Grzesiak W., Analysis of Resistance vs. Votage dependence in Low Regions for Precisions Value Resistors, Proc. of European Microelectronics, Packaging and Interconnection Symposium, Cracow 2002, Poland, 16-18 June 2002 , p. 346-349.