CHARACTERISATION OF VACUUM OUTGASSED PLASTIC MATERIALS FOR MINIATURE RELAYS

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Keywords: miniature relays, vacuum outgassing, vacuum cleaning, functional reliability, mass spectroscopy, plastic materials for electronics

Abstract: Vacuum outgassing as a cleaning procedure was introduced and its influence on the contact characteristics and reliability of miniature relays was examined. Three plastic materials: Lexan, Araldit and Ultramid were considered. The conditions of high vacuum ($1x10^{-6}$ mbar) and the temperature of 135°C were provided by the laboratory experimental equipment where plastic materials were outgassed for 48 hours. The gas mixture obtained by the outgassing procedure was analysed with the mass spectrometer. Beside other gases saturated and unsaturated hydrocarbons C_nH_m with low number of carbon atoms were detected. The most intensive contamination of the relay atmosphere with hydrocarbons was found for Araldit while the other two materials have rather low outgassing rate therefore its influence on the relay atmosphere contamination is negligible.

Karakterizacija vakuumsko razplinjenega plastičnega materiala za miniaturne releje

Ključne besede: releji miniaturni, razplinjevanje vakuumsko, čiščenje vakuumsko, zanesljivost delovanja, spektroskopija masna, materiali plastični v elektroniki

Povzetek: Predstavljen je vpliv vakuumskega razplinjevanja kot čistilnega postopka na izboljšanje kontaktnih lastnosti in zanesljivosti delovanja miniaturnih relejev. Sistematično smo raziskali vakuumsko razplinjevanje treh plastičnih materialov za releje: Lexan, Araldit in Ultramid. V visokem vakuumu pri tlaku v razredu $1x10^{-6}$ mbar in 135°C smo v laboratorijski eksperimentalni napravi 48 ur razplinjevali plastične materiale. V plinski mešanici sproščenih plinov pri razplinjevanju smo z masnim spektrometrom ugotovili vrsto primesi, med drugim tudi nekatere nenasičene ogljikovodike C_nH_m z nizkim številom ogljikovih atomov, ki jih je največ v Araldit u in povzročajo onesnaženje atmosfere v releju. Ostala dva materiala imata nizko stopnjo razplinjevanja in na onesnaženje atmosfere v relejih le malo vplivata.

1. Introduction

It is very important to know the outgassing properties (1-4) of plastic materials for electronic components because they to the great extent influence on the quality and the reliability of miniature relays. The increasing of the contact resistance (5-8) as well as the reliability of a relay are dependent on the outgassing rate of its components. Therefore we examined the outgassing procedure as a cleaning procedure for the surfaces of three different materials which are most frequently used for miniature relay construction. Detailed analysis showed that the concentration of gas impurities depend on the materials as well as on their treatments in different technological phases.

2. Experimental

Experimental part of our work was done in the laboratory experimental vacuum setup (Fig. 1) which was additionally equipped with the mass spectrometer Leisk SM 1000M for gas analysis during vacuum outgassing procedure. In high vacuum three plastic materials Lexan, Araldit and Ultramid were outgassed. Samples of equal mass were prepared for that purpose.

First the composition of the outgassed gas mixture was determined for the empty vacuum chamber at the room temperature (23°C) and after the baking for 24 hours at 135°C and the total pressure of $4.4x10^{-6}$ mbar. After heating of the outgassing vacuum chamber the individual plastic materials were outgassed first for 2 hours at the room temperature and then for 48 hours at 135°C. The total pressure for both measurements was about $1x10^{-6}$ mbar. The gas mixture was controlled also after 24 hours.

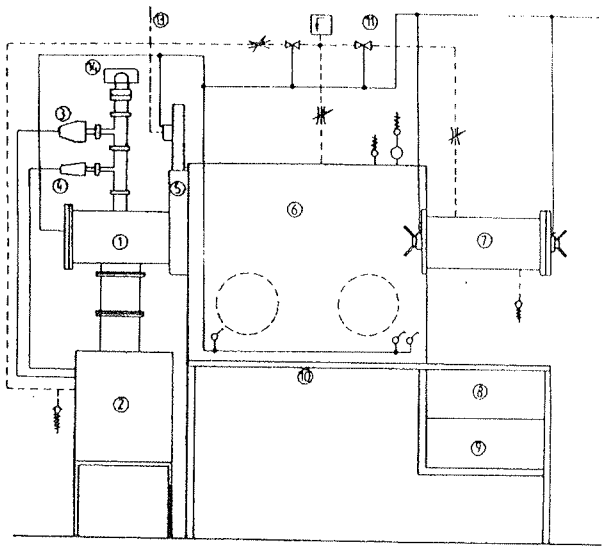

Fig. 1. Experimental vacuum system for outgassing process: 1-vacuum chamber, 2-vacuum system, 3-PNG head, 4-PRN head, 5-mass spectrometer, 6-plate valve, 7-N_2 chamber.

3. Results and discussion

Mass spectrum presented in Fig. 2 was taken after 24 hours baking of empty vacuum chamber at 135°C and $4.4x10^{-6}$ mbar. High peaks of hydrogen (m/e=2) and water vapour (17 and 18) can be seen together with the peaks belonging to the hydrocarbons from the rotatory vacuum pump. The next spectrum (Fig. 3) indicates the composition of the gas mixture after 2 hours of outgassing of Lexan (23°C, $1.6x10^{-5}$ mbar). Mainly hydrogen (2) and water (18) peaks are detected. Gas mixture of the outgassed Lexan was analysed (Fig. 4). Spectrum is nearly identical to the one taken after 24 hours (the same temperature and pressure) not presented here. We made a conclusion that the Lexan surface has been completely outgassed already after 24 hours.

Araldit was considered next. Its outgassing was intensive already at the room temperature and the total pressure $8x10^{-6}$ mbar (Fig. 5). Beside hydrogen and water peaks high peaks belonging to hydrocarbon with m/e=30 appeared. It is present (Fig. 6) also after the longest period of outgassing (48 hours, 135°C, $1.2x10^{-5}$ mbar). Mass spectrum of Ultramid (Fig. 7) was taken after 2 hours (23°C, $1x10^{-5}$ mbar). High peaks belonging to hydrogen and water were noticed which disappeared already after 24 hours (135°C, $5.4x10^{-6}$ mbar) of outgassing so that the spectrum after 48 hours (Fig. 8) does not differ significantly from that one taken after 24 hours of outgassing.

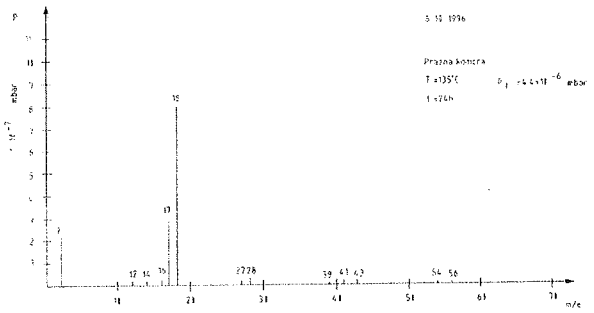

Fig. 2. Mass spectrum of the outgassed empty chamber (135°C, 24 hours, total pressure $4.4x10^{-6}$ mbar).

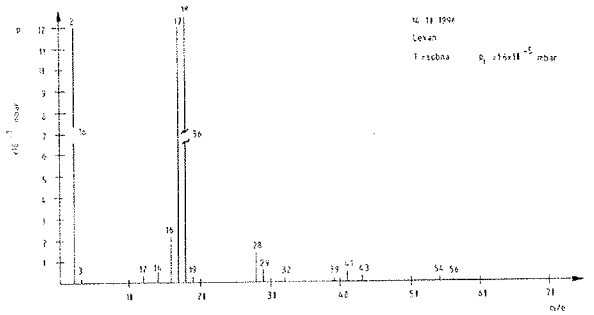

Fig. 3. Mass spectrum of the outgassed products made of Lexan (23°C, 2 hours, total pressure $1.6x10^{-5}$ mbar).

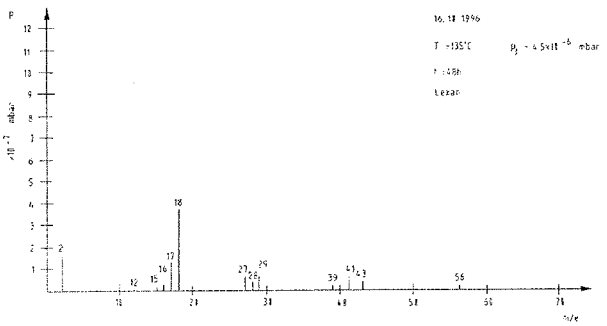

Fig. 4. Mass spectrum of the outgassed products made of Lexan (135°C, 48 hours, total pressure $4.5x10^{-6}$ mbar).

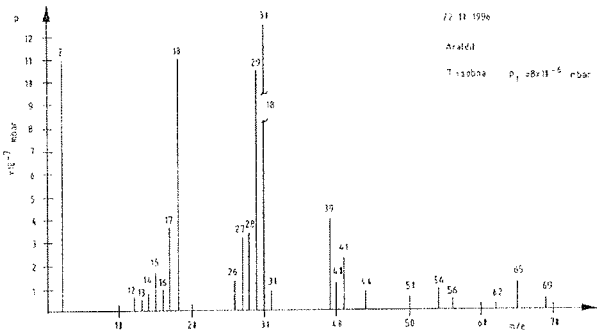

Fig. 5. Mass spectrum of the outgassed products made of Araldit (23°C, 2 hours, total pressure $8.0x10^{-6}$ mbar).

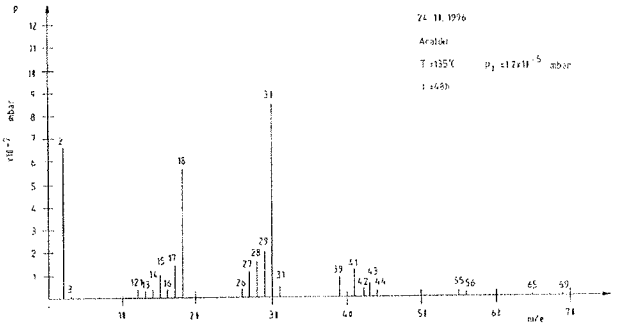

Fig. 6. Mass spectrum of the outgassed products made of Araldit (135°C, 48 hours, total pressure $2.1x10^{-5}$ mbar).

It must be mentioned that taking mass spectra some corrections like different specific ionisation energies of gases and the decreasing of the quadrupole mass spectrometer sensitivity with the increasing specific mass were not taken into account.

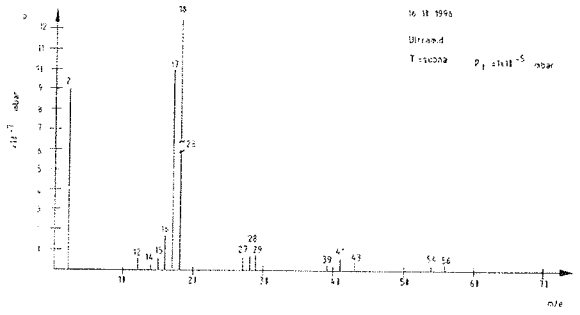

Fig. 7. Mass spectrum of the outgassed products made of Ultramid (23°C, 2 hours, total pressure 1x10^{-5} mbar).

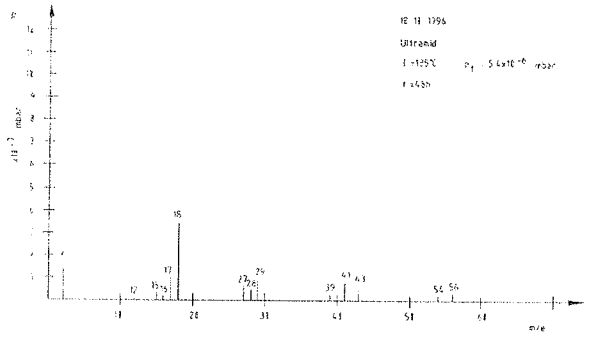

Fig. 8. Mass spectrum of the outgassed products made of Ultramid (135°C, 48 hours, total pressure 5.4x10^{-6} mbar).

4. Conclusions

Gas mixture obtained as a residue atmosphere after outgassing of the three most common plastic materials used for miniature relays (Lexan, Araldit and Ultramid) was analysed with the quadrupole mass spectrometer. Hydrogen, water and hydrocarbons (mostly the one with m/e=30) were detected.

After 24 hours of outgassing at 135°C and total pressure of about 1x10^{-6} mbar all the materials except Araldit were completely outgassed.

Because of the high outgassing rate of Araldit in comparison with Lexan and Ultramid the relay inner atmosphere (when Araldit was used) was highly contaminated. As a consequence the contact resistance of miniature relays was considerably increased.

5. References

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