Reliability of automotive electronic components under conditions of alternating loads

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Generalized Hooke's law for a silicon single-crystal sensitive element of pressure sensors of automobile electronics showed that at a tension arising in sensitive elements of sensors under conditions of real operation of car engines, there can be defects in crystal lattice which cause a hysteresis of the device properties. It is established that experimental data on frequency distribution of hysteresis size of the sensors electrophysical parameters can be described by the normal law of distribution of random variables. We offer a mathematical model of hysteresis emergence and change in sensor elastic elements of mikroelektromechanical structures used in automobile electronics. The model was constructed using a method of polynomial regression of experimental data and allows to define reliability of commercially available sensors. It is shown that in order to reduce the magnitude of the temperature hysteresis of the output signal in integrated pressure sensors, it is necessary to eliminate the causes of elastic stresses in their structures.Optimization of sensors technological process (changing technology of holes formation in the glass, upon which the membrane is attached) allowed to reduce the hysteresis sensor output to 0.01 mV instead of 0.07 mV for base technology.

Keywords: *pressure sensors, automotive electronics, defects and hysteresis of parameters, MEMS, integrated chip, reliability, dislocations.*

REFERENCES

[1] Sysoyeva S.A. *Komponenty i tekhnologii — Components and technologies*, 2006, no. 7, pp. 18–25.

[2] Iukovich E.V. *Elektronnye komponenty — Electronic components*, 2003, no. 2, pp. 23–24.

[3] Adarchin S.A., Kosushkin V.G., Maksimova E.A. Mekhanizmy degradatsii mikroelektromekhanicheskikh struktur datchikov davleniya [Mechanisms of degradation of microelectromechanical structures of pressure sensors]. *Trudy MGTU im. N.E. Baumana no. 587 "Metody issledovaniya i proektirovaniya slozhnykh tekhnicheskikh system"* [Proceedings of the Bauman MSTU no. 587 "Methods of research and design of complex technical systems"]. Moscow, BMSTU Publ., 2004, pp. 48–56.

[4] Sergeyev V.S., Kuznetsov O.A., Zakharov N.P., Letyagin V.A. *Napryazheniya i deformatsii v elementakh mikroskhem* [Tension and deformations in chip elements]. Moscow, Radio i svyaz, 1987, 386 p.

[5] Muzhichenko O.G., Plis N. *Elektronika: Nauka, tekhnologiya, biznes — Electronics: Science, Technology, Business*, 2000, no. 6, pp. 63–64.

[6] Chernyshev A.A. *Osnovy nadezhnosti poluprovodnikovykh priborov i integralnykh mikroskhem* [Bases of reliability of semiconductor devices and integrated chips]. Moscow, Radio i svyaz, 1988, 356 p.

[7] Sze S.M., ed. VLSI Technology. McGraw-Hill, 1983.

[8] Polyakova A.L. *Deformatsiya poluprovodnikov i poluprovodnikovykh priborov* [Deformation of semiconductors and semiconductor devices]. Moscow, Energiya, 1979, 168 p.

[9] Kontsevoi Yu.A., Litvinov Yu.M., Fattakhov E.A. *Plastichnost' i prochnost' poluprovodnikovykh materialov i struktur* [Plasticity and durability of semiconductor materials and structures]. Moscow, Radio i svyaz, 1982, 240 p.
[10] Adarchin S.A., Kosushkin V.G., Maksimova E.A. Metodika rascheta velichin uprugikh napryazheniy v mikromekhanicheskikh strukturakh datchikov davleniya [Calculation method of elastic tension values in MEMS of pressure sensors]. *Trudy MGTU im. N.E. Baumana no. 587 "Metody issledovaniya i proektirovaniya slozhnykh tekhnicheskikh system"* [Proceedings of the Bauman MSTU no. 587 "Methods of research and design of complex technical systems"]. Moscow, BMSTU Publ., 2004, pp. 37–47.
[11] Osipyan Yu.A., ed. Elektronnye svoistva dislokatsiy v poluprovodnikakh [Electronic properties of dislocations in semiconductors]. Moscow, Editorial of URSS, 2000, 320 p.

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