Streszczenie rozprawy doktorskiej
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"Analiza teoretyczna i doświadczalna możliwości zastosowania termoakustycznej metody pomiaru do badania szczelności obudów elementów elektronicznych"
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Hermeticity of electronic packages is a very important reliability parameter, especially in a case of electronic components working in extreme conditions and when a high reliability is necessary. The main reason for controlling the hermeticity is to protect the internal structure of the component from the influence of moisture and other contaminants. The lack of hermeticity can lead to different failure modes, including corrosion of thin metal layers and wire bonds, open and short circuits, increase of leakage currents and a degradation of the electric isolation. Because of a variety of packages designs and different requirements for their hermerticity, there is a number of hermeticity test methods, both fine and gross leak detection methods. The thermoacoustic test method, which is an example of a gross leak detection method, bases on the measurement of the acoustic signal generated by the periodic heat dissipation in an electronic component, closed in a test chamber and driven by an external control signal. The main advantage of the termoacoustic test method over other gross leak detection methods included in the industrial standards is its non-destructive character. Another advantage is that the method allows to estimate the geometrical size of the leak in micrometers, while other methods give only the value of parameters indirectly related to the leak size, such as an increase of the reverse currents. The first part of the dissertation contains a short introduction to the electronic packages technology and reliability including: criteria of their classification to hermetic and non-hermetic packages, their main functions and construction of selected metal and plastic packages. Main failure modes of the electronic packages leading to the loss of their hermeticity and being the result of the leaks were also described. A detailed description is given for different methods used currently in the industry and for alternative methods proposed in the literature. The main limitations of those methods were also given. For the purpose of the evaluation of the thermoacoustic method usability for the hermeticity testing of electronic packages two different measuring setups were designed and tested. The measuring setups were designed for measurements of amplitude and phase frequency thermoacoustic characteristics, which are the main experimental data used in the method. From the point of view of the proper interpretation of the experimental characteristics it was very important to choose the correct mathematical model. In the dissertation two models, CRC and CRLC based on a transformation of the system containing the acoustic chamber and the tested component to the equivalent electric circuits, were tested. The CRLC model was chosen, basing on the better approximation of the experimental data. Different theoretical approaches were compared with the experimental thermoacoustic characteristics of the packages with a known leak size and the best model was chosen. In the experimental part of the dissertation a number of thermoacoustic characteristics of metal TO-18, TO-39, TO-3 and plastic TO-220, TO-92 packages were measured, including air-tight packages and packages with a leak of a known size. The influence of the background signal representing the air-tight package was tested and procedure of including that background signal in the calculations was presented. The origin of the background signal was also analyzed and modeled. It appeared that the background signal is composed of three components: thermal wave component, drum effect component and piston effect component. The mathematical model based on the estimation of the influence of each of those components, was proposed in the dissertation. In the final part of the thesis the influence of different factors on a detection ability of the thermoacoustic test method was discussed. It appeared that very important is the influence of the effective volume, depending mostly on the internal volume of the package. It was shown that the sensitivity of the thermoacoustic test method increases as the effective volume decreases. The influence of the improper attachment of the silicon die to the metal base of the package was also analyzed and it was proven that such defects can be distinguished from the leaking packages. The method presented in the dissertation can be still developed and improved for both metal and plastic packages. The method can be used in the quality control departments as an alternative for a destructive gross leak detection method such as a dye penetrant and pressure bomb tests. It was proven that the thermoacoustic test method can be used for the evaluation of the hermeticity of electronic devices, which was the thesis of the dissertation.