Integration of commercial PZT thick films on various LTCC substrates for microsystem applications

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Key words: PZT, Thick Film, Screen Printing, LTCC, Microsystem

ABSTRACT

LTCC (Low Temperature Cofired Ceramics) technology has been proven to be successfully applied in various microsystem applications including: sensors, actuators, microreactors, etc. Very often the required functionally of a microsystem involves electro-mechanical coupling, for example: micro-valve or micro-pump actuation. In many cases a hybrid approach is used, where the mechanical movement is created by electromagnetic actuator made in MEMS technology. Attempts have been also made to integrate bulk PZT ceramics with LTCC. It must be pointed out that all of the mentioned solutions either increase the cost of production or decrease the manufacturability and reliability of the final devices. Therefore a new solution has been proposed involving integrated screen printed PZT thick films developed and offered by InSensor A/S.

It has been known from previous work that integration of PZT thick films with LTCC involves potential problems of thermal matching and chemical compatibility at the processing temperatures between the functional film, the substrate and the electrodes. Therefore thorough investigations on the influence of the substrate and the diffusion barrier on the quality and properties of the active PZT layers have been conducted.

Six types of ceramic substrates have been tested including: five different LTCC materials produced by leading LTCC suppliers: DuPont, ESL, Hereaus and 99.5% alumina substrate that has been used as reference. The substrates have been fabricated according to the recommended procedures. The bottom electrode acting as a diffusion barrier layer, the PZT thick films (35 µm thick) as well as top silver electrodes have been screen printed.

Piezoelectric activity of the PZT layers has been determined by means of Sawyer-Tower setup and the basic ferroelectric parameters have been measured and compared with the reference. Moreover the structure of the thick films as well as the barrier layer has been investigated using SEM. The impedance spectra of the PZT thick films have been also measured. In order to investigate the direct piezoelectric properties of the films apparent d_{33} measurements have been performed.

According to the obtained results the PZT thick films have been active in case of all the tested substrates. Nevertheless some of the substrates exhibit a quite significant variation of the piezoelectric properties whereas one of the investigated LTCC substrates has given very reproducible results that are comparable with the reference. Due to very promising results the presented work will be continued towards development of applications involving integrated PZT thick films with LTCC ceramics especially in the field of microsystems.