THE DIELECTRIC PROPERTIES AND THE CONSTRUCTION OF POLYMER-BASED MICRO FLUIDIC DEVICES USING MICROWAVES

Abdirahman Yussuf*, Wing K. Tam, Michael Malcmann and Nguyen Tran
Industrial Research Institute of Swinburne, Swinburne University of Technology

ABSTRACT

The micro fluidic devices under investigation are MEMS devices which in general, consist of a number of pre-designed minute grooves, micro-machined in two matching polymer material substrates, which are subsequently bonded together to form sealed micro-channels to pass fluid through. Hence they are called micro fluidic devices. A micro fluidic channel is of the order of 100µm in width and a few mm in length. A successful seal must pass the leak test under a pressure of several bars for it to be useful.

Microwave technology is a potential candidate for this bonding operation because of its preferential heating capability especially when the bonding material has a high loss factor compared to the substrate material. The bonding is always done blind. Once the bonding material is heated with microwaves to its melting point, a seal is achieved through a preset assembling pressure. It should be appreciated that the width of the bonding material is also very narrow of the order of 100µm or less and that conventional heat is not differential that is both the substrate and the bonding material must be heated to their melting temperature.

The selection of the substrate and the bonding material is important. Fortunately most substrate materials are polymer, which are transparent to microwaves. The substrate material is chosen to be PMMA or polycarbonate that is virtually transparent to microwaves. The bonding material is a special conductive polymer that is a polymer modified by nano-size particles of a conducting material.

We study the dielectric properties of the PMMA polymer and the conductive polymer at 2450 MHz at different temperatures up to 140^0C using coaxial open ended probe and a network analyzer. The measurement confirms that the dielectric loss factor of the PMMA substrate and the conductive polymer show a clear difference, which suggests that differential heating is possible with microwave heating.

The next problem we have to tackle is to focus the microwave energy to sealing strips around every channel. This is quite a challenge because the amount of absorbing material is so minute.

The accurate dielectric properties are very essential for the successful development of the bonding process because they are needed to simulate the field distribution across and along the channel in a microwave cavity. We observe the differential effects through the variation in the field distribution. The impedance response from the simulation provides us with some clues to match the microwaves to the bonding material. We verify the field distribution by using fiber optic probes to measure the temperature of the bonding strips and the substrate since the square of the electric field is proportional to the temperature. We then use a pre-tuned three stub tuner with an impedance autotuner to achieve a perfect match.

The paper discusses the dielectric properties of PMMA and the conductive polymer and their variation with temperature. We will also discuss the results of the bonding operation and the subsequent pressure tests. From the results obtained, we are confident that microwaves can be used to fabricate micro channels for any micro fluidic devices.