Développement d'une méthode innovante de mesures des propriétés thermomécaniques de films minces. Application à un dispositif imageur

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Abstract : Polymers are very widespread in microelectronics. In addition to their relevant electrical and optical properties for integration, their thermomechanical properties generally exhibit a high contrast with semiconductor substrates, but also with other materials also integrated into microchips, like oxides or metals. This mismatch between materials generally leads to a sharp increase of stresses in the various layers under consideration, which in returns results of a sharp increase in the wafer curvature. Excessive stresses can lead to cracking or delamination, threatening the mechanical integrity of the structure. Knowing the properties of each layer, especially polymer films, enables designers to verify the compatibility of integrated materials and guarantee component reliability. However, to achieve this goal, it is mandatory to develop characterization techniques, especially for thin films deposited on substrates.

Thus, the aim of this work is to develop an experimental method to determine the thermomechanical properties of integrated layers, and then to verify the mechanical integrity of microelectronic devices using analytical or numerical simulation tools. This method is based on measuring the variation of curvature during thermal cycles. Then the completion of the polymer cross-linking process can be checked and its temperature of glass transition can be determined. By measuring the thermally induced curvature of two distinct substrates with the same deposited polymer material, the biaxial modulus and the coefficient of thermal expansion of the film are determined. By characterizing a large number of polymers using this technique, we can build up a materials database that can be supplemented with other integrated materials. These data are used in modeling to predict the strain and stress levels of several devices used in microelectronics.

In particular, we will study the case of image sensors by performing a predictive calculation of strain and stress distributions of stacks in order to examine the compatibility of different materials. We will

also work on the mechanical integrity of these devices, to guarantee their manufacture and reliability over time. We will show that the material selection is eased by structural modeling and a method to study crack initiation and propagation using numerical models.