Study of failure mechanisms in thin metallic films on flexible substrates for flexible electronic

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Abstract: Over the past 20 years, new improvements in materials and processes led to the development of printed flexible electronics. Flexible electronics devices subjected to bending, twisting, or stretching during their lifetime, the development of device with high reliability is therefore of great importance for the efficiency of electrical connection. This work investigates the mechanical reliability of inkjet or screen-printed Ag thin films on polyimide substrates dedicated to the electrical interconnection of active components. Expected mechanical failure modes are film cracking and buckling delamination.

First of all, in order to characterized the two mechanisms, tensile tests are performed under an optical microscope to follow cracks and under an optical interferometer to follow buckles. In order to obtain crack spacing evolution during deformation, an image processing is realized. Two types of cracks are observed: long and straight cracking for thick films and small and zigzag shape cracking for thin films. The evolution of buckles shape with imposed tensile deformation is characterized.

In a second time, in order to understand experimental observations, mechanical failure modes are analysed with finite elements models. The origin of the two types of cracking are explained by a geometrical effect of film thickness. An elastoplastic shear lag bidimensional model gives upper and lower bonds of crack spacing during deformation. A three-dimensional model allows identification of cohesive zone model parameters at film/substrate interface, from experimental buckle shape. An adhesion energy of 2 J.m-2 , a critical strength of 20 MPa and a mode mixity parameter of 0.4 are determined. These values are in good agreement with literature.