Thermomechanical Properties Of Elastomeric Stamps For Micro-Transfer Printing Applications

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Abstract

Micro-transfer printing (MTP) enables mass-transfer of wafer-level chips having lateral dimensions ranging from 3 x 7 um to 650 x 650 um to a nonnative substrate. This is accomplished with an elastomeric stamp containing micrometer scale posts that have been precisely defined using photolithography. MTP is highly parallel and is capable of transferring tens of thousands of devices in a single MTP operation. Transfer yields and placement accuracy, however, are dependent on the performance of the micrometer structured elastomer stamp. During extended MTP use, the stamp is subjected to changes in temperature due to the moving mechanical components of the printer which can have unwanted effects on device placement accuracy.

In this work, we utilize the Structural Mechanics Module with the Heat Transfer in Solids and Solid Mechanics interfaces in COMSOL Multiphysics®. The simulation is based off the Thermal Expansion in a MEMS device model from the Application Library. In this study, an elastomeric stamp with a 3 x 3 array of microstructured posts are simulated to investigate heat distribution and thermal expansion. Volume expansion of the stamp and movement of the posts are measured. Preliminary results show the thermal expansion of the stamp is nonlinear due to the fixed constraint at the base of the stamp which reflects experimental conditions where the stamp is mounted to a rigid, noncompliant substrate such as glass or silicon. Volume expansion of the post appears to be negligible due to the size of the features. The volume expansion of the stamp base, however, is nonnegligible and effects the array spacing.

Given the high precision and accuracy needed to successfully MTP thousands of micron sized devices, knowing the behavior of the stamp under various temperatures is critical. These initial simulations show that temperature increases can deform the stamp, potentially causing misalignment of devices during the MTP process. Future work will include the simulation of various stamp and post designs to mitigate the effects of thermal expansion. This will give industries utilizing MTP a tool to design stamps capable of transferring more devices than previously possible with predictable placement accuracy.