Electromagnetic Release Process for Flexible Electronics

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Abstract

Flexible electronics are temporarily affixed to a rigid carrier such as glass or silicon prior to device fabrication to facilitate robotic handling of the device, but also to allow optical lithography to stay within overlay design registration budget; without the rigid carrier, a freestanding flexible substrate such as polyimide would distort unacceptably during even minor temperature excursions due to its high coefficient of thermal expansion. Post fabrication the device must be released from its temporary carrier. Others have used UV-release of a temporary adhesive (bond-debond) [1], solvent release [2], backside laser ablation [3], backside sacrificial grinding, backside wet chemical [4,5] and plasma etching [4], mechanical separation [2], and thermal release [2] to affect this release. Each release technique possesses one or more significant disadvantages, including added cost, added processing time, limited throughput, added processing steps, and increased opportunity to introduce defects to a nearly finished device. A new low-cost, clean, chemical-free, high throughput carrier release technique based on electromagnetic heating of a ferromagnetic thin film is proposed to address the limitations of current release processes. The proposed release technique uses a thin film (5 skin depths or more) of high magnetic permeability material deposited directly onto the rigid carrier. A spin-coatable flexible substrate such as polyimide is deposited on top of the magnetic film, followed by curing. The flexible electronics are then fabricated on top of the polyimide. The completed device is released from the carrier by exposing it to a very brief perpendicular AC magnetic field generated by an induction coil. The temperature of the magnetic film rises very rapidly and thermally ablates a thin layer of the polyimide that is deposited directly on top of it. Carrier release is affected by the production of ablation product gases and the ensuing interfacial pressure rise. This process results in a clean, rapid, chemical-free, release of the carrier from the finished device, and the carrier can be cleaned and reused again and again since it is never consumed in the process. COMSOL simulation studies of this inductive heating release process were conducted to estimate 2D temperature history profiles at the metal/polyimide interface. The interface temperature is needed to predict the time and spatial location of ablation onset. A smooth, "wave-like" release of the device is desired to avoid localized over-pressurized regions of isolated ablation gases—these pockets of high pressure can damage the device by tearing the flexible substrate. Simulation results can rapidly speed the process of designing the proper shape and placement of the induction coil to affect this smooth ablation release. Additionally, when considering scale-up for larger substrate sizes, the induction coil or device stack may need to be rastered relative to each other—again simulation studies can be used to rapidly design an appropriate raster program for smooth release.

Reference

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