ABSTRACT:

The Origin and Control of Stress in Heat Spreading Films for Heterogeneous Integration

Residual stress in thin films leads to reliability issues associated with cracking and delamination, as well as yield issues associated with die and wafer warp. The residual stress observed at room temperature or during operation has two components: (i) intrinsic stress that develops during film deposition, and (ii) thermal stress associated with temperature changes, such as cooling to room temperature from the film deposition temperature. The thermal stress depends on the biaxial modulus and Poisson's ratio of a film, which can often significantly vary from bulk values and also vary with deposition techniques and deposition conditions for a given technique. These property variations have been linked to the variations of the microstructure of polycrystalline films. The intrinsic stress can range from compressive stresses on the order of GPa to tensile stresses on the order of GPa, depending on minor changes in deposition conditions. The development of intrinsic stress during film deposition has been linked to microstructure evolution and has been extensively studied in metal films. Less is known about hard materials with low atomic mobility.

Development of new methods and materials for monolithic and 3D chiplet heterogeneous integration is setting the pace for improvements in performance of microelectronic systems, which, by some measures, is exceeding expectations set by Moore's law. A key challenge to achieving more densely integrated systems is thermal management. This is driving intense investigation of integrated films of heat spreading materials such as diamond, AlN, and BN. Recent progress in understanding the origin and control of stress and mechanical properties of these materials will be reviewed. Methods for stress management and mitigation of the effects of stress will also be discussed.