IN-SITU DEFORMATION MONITORING OF THIN ELECTROCHEMICALLY DEPOSITED COPPER LINES DURING THERMO-MECHANICAL PULSING

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In semiconductor industry, the development of the last years led to smaller and smaller devices in order to maximize efficiency and minimize costs. As a result, a miniaturization of the test structures is required as well as a proper method to monitor gradual deformation processes during repetitive thermal cycling. Thin metal films, e.g., Cu are commonly used in power semiconductor devices. Rapid temperature changes combined with a mismatch in thermal expansion coefficients of the different materials in the layer stack lead to thermo-mechanical stresses and as a result to deformation of the metallization.

In order to realize high heating rates (up to 106 K/s) and to be able to observe deformation on the metallization surface, polyheater structures are used. There, a polysilicon layer works as a heating plate (Joule heating) for the Cu layer above, allowing repetitive heating and cooling on short timescales. The temperature of the system is measured using an integrated sensor. Since the deformation features, e.g. slip bands and extrusions, are on the sub-micron length scale, a scanning electron microscope (SEM) is necessary for in-situ deformation monitoring. This novel approach provides the possibility to observe the gradual deformation of metallizations under variable test parameters at high magnification and in vacuum.

As test structures, 20x20x300 μm^3 Cu lines with different types of copper on top of the polysilicon were chosen to be able to observe the surface as well as the side walls of a metallization structure. It is revealed, that different Cu grain microstructures lead to differences in deformation behavior during thermo-mechanical cycling. Videos of the deformation process and EBSD images are presented to demonstrate the method.