Cantilever test structures for stress characterization in multilayer MEMS membranes

Federica Capra[a*], Angelica Baldini, Matteo Bisogni, Chiara Carra, Filippo Daniele, Filippo D'Ercoli, Marco Dosi, Silvia Nicoli, Mattia Pallaro, Andrea Taini, Lorenzo Tentori, Igor Varisco

[a] *STMicroelectronics, Via C. Olivetti 2, Agrate Brianza (MB), 20864 Italy*

Residual stress of thin films is a critical aspect which has to be carefully taken into account during both design and manufacturing of MEMS sensors and actuators.
In this respect, it's extremely important to understand the mechanical behaviour of MEMS membranes where a specific deflection can directly impact the MEMS device performance.

The stress of one or more films that are composing a moving membrane cannot be measured by conventional stress characterization approaches.
In this work, a method to extrapolate the residual stress of a multilayer MEMS membrane has been evaluated. This technique is based on the characterization of an array of cantilevers test structures which are fabricated on silicon wafers employing a simplified MEMS process flow.
Upon release, the cantilevers deflect to partially relieve the unbalanced residual stress in the thin films. Visible light interferometry is employed to quantify the deflection of the cantilevers, allowing for the calculation of residual stress in all the integrated thin films.

The deformation profile of the cantilevers test structures (Fig 1) has been measured by interferometry on Rudolph Technologies NSX 330 26 sites per wafer. By matching the measured displacement and the simulated one, residual stress has been reconstructed through finite-element analysis (FEA) with COMSOL Multiphysics® (Fig 2).

The output of this work is to provide the fundamental mechanical information of the multi-stack layer needed to properly assess the design and the validation of the MEMS membrane. The ability to probe local stress variations (Fig 3) opens up new opportunities for stress analysis in multi-layer stacks, which are prevalent in complex MEMS structures. The proposed method provides also a valuable tool for optimizing the connection between MEMS design and fabrication phases.

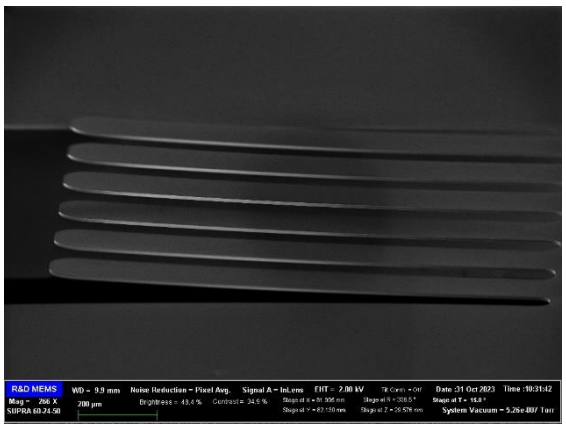

Figure 1. SEM image of released cantilever test structures.

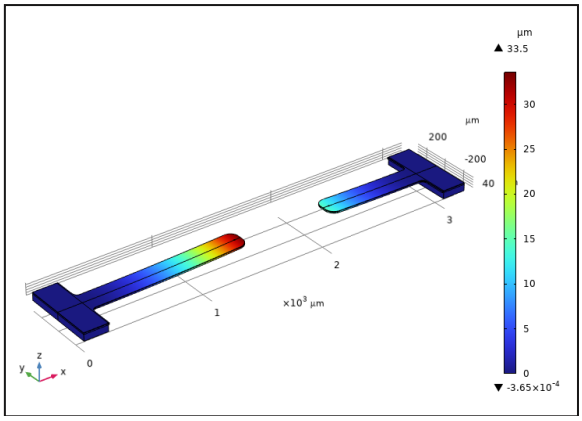

Figure 2. Cantilever test structures simulation, out-of-plane displacement.

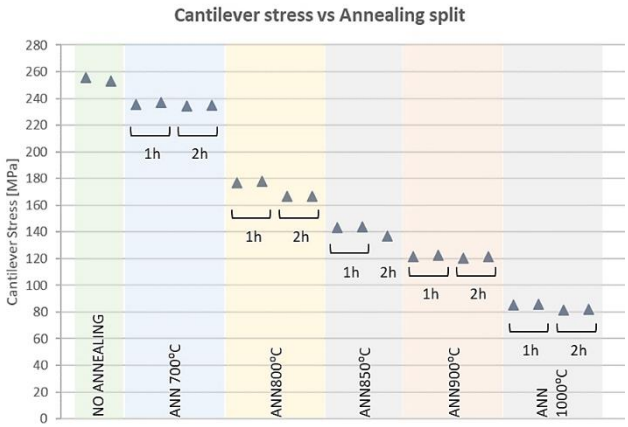

Figure 3. Cantilever stress trend as a function of thermal budget.