Stiction failure in microswitches due to elasto-plastic adhesive contact and cyclic loading

Ling Wu*, Jean-Claude Golinval, Ludovic Noels

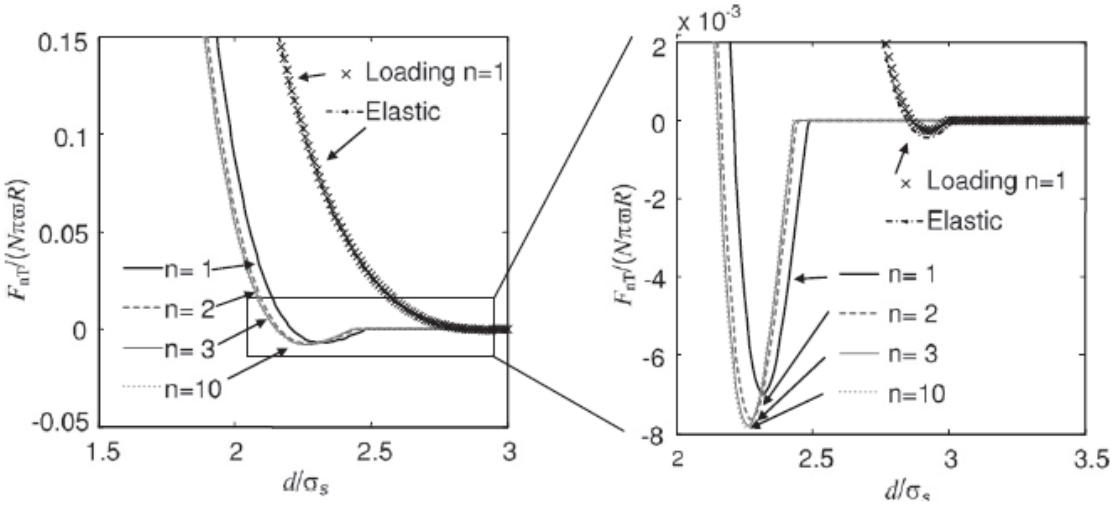
University of Liege, Department of Aerospace and Mechanical Engineering, Computational & Multiscale Mechanics of Materials, Chemin des Chevreuils 1, B-4000 Liège, Belgium

*Corresponding author. Tel:+32 43664826 E-mail address: L.Wu@ulg.ac.be

Undesirable stiction, which results from contact between surfaces, is a major failure mode in micro-switches. This is especially true when contact happens between surfaces where elastoplastic asperities deform permanently until the surfaces reach plastic accommodation. Indeed before or at accommodation, the adhesive forces can become so important that the two surfaces remain permanently glued, limiting the life-time of the MEMS.

To predict the behavior a micro adhesive-contact model is developed, which account for the surfaces topography evolutions during elasto-plastic contacts. This model can be used at a higher scale to study the MEMS behavior, and thus its life-time. The MEMS devices studied here are assumed to work in a dry environment. In these operating conditions only the Van der Waals forces have to be considered for adhesion.

For illustration purpose, an electrostatic-structural analysis is performed on a micro-switch. To determine the degree of plasticity involved, the impact energy of the movable electrode at pull-in is estimated. Thus the maximal adhesive force is predicted using the developed model.



Within this formalism, the cyclic loading and accommodation effects can be taken into account, as represented on the picture, which shows the non-dimensional force vs. separation distance of two rough surfaces after different cycle numbers.

[1] L. Wu, J.-C. Golinval, and L. Noels. "A Micro Model for Elasto-Plastic Adhesive-Contact in Micro-Switches: Application to cyclic loading." Tribology International 57 (2013): 137-146.
[2] L. Wu, L. Noels, V. Rochus, M. Pustan, and J.-C. Golinval. "A Micro-Macroapproach to Predict Stiction due to Surface Contact in Microelectromechanical Systems." IEEE/ASME Journal of Microelectromechanical Systems 20, no. 4 (2011): 976-990.
[3] L. Wu, V. Rochus, L. Noels, and J.-C. Golinval. "Influence of Adhesive Rough Surface Contact on Micro-Switches." Journal of Applied Physics 106, no. 11 (2009): 113502.