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A new methodology for RF MEMS Contact simulation

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ABSTRACT

Until nowadays, surface roughness effects were ignored in the analysis, due to the difficulty to generate a rough surface model and also to simplify the model in order to reduce calculation time. However, many engineering fields, such as MEMS, seek to improve the behaviour of the system at the surface level or the interface between surfaces (capacitive contact [1] and DC contact [2]),. Thus, with the advance of numerical capabilities, the topography of the surface can be included in finite element simulations.
The aim of this work is to present a new methodology that will allow the simulation of the DC and capacitive contact of RF MEMS devices through finite element multi-physic simulation and surface characterization.

The sample under discussion consists of a thick electroplated gold layer (2.5µm) covered with a thin Si3N4 dielectric layer of 0.2µm and a permittivity of 6.6. The sample area is 130x80µm2.

A variety of methods for creating rough surfaces in finite element models have been proposed. But all of these methods deal with a statistical or fractal description of the surface roughness. The originality of this work relies on a novel approach by using a reverse engineering method to generate the real shape of the surface. Figure 1 describes the full method developed on ANSYS platform. We used an optical profilometer to capture three-dimensional data points of both contact surfaces. Then, using Matlab functions, we convert the closed surface from a stereolithographic format to an ASCII file compatible with ANSYS Parametric Design Language (APDL). We have used the Coon's patches formalism to generate the surface followed by a bottom up solid modeling to create the block volume with the rough surface on the top. This numeric approach is validated by comparing the value of the capacitance calculated from multiphysic simulation with an analytical model derived from the real surface (figure 2). The obtained results have shown very good agreement better than 5%. It has to be outlined that there is still some discrepancies with respect to the measurements that are related to fringing effects and roughness on the beam that were not taken into account. Additional simulations are on going to calculate the capacitance between two rough surfaces. This method has also been implemented to investigate the physic of DC contact. The model consists of an electroplated gold layer defined as a flexible material (Figure 3) and the target surface (indentor) is assumed to be either a flat, smooth and rigid surface or an evaporated gold layer defined as a flexible material.

We used this method to predict the real contact area between rough surfaces as a function of the applied force (see figure 4) using the augmented Lagrange method.

From the pressure distribution and size of each contact spot it is possible then to use an analytical expression to extract the electrical contact resistance using Maxwell spreading resistance and Sharvin resistance [3,4,5]. The final analysis and the results should be presented in the final paper.

The method developed as been validated for both DC and capacitive RF MEMS and will be a very efficient TCAD tool for investigating the impact of materials, roughness, technological process, topology on the quality and the repeatability of the RF MEMS contact. It could be also used to investigate the degradation mechanism in the case of reliability studies.

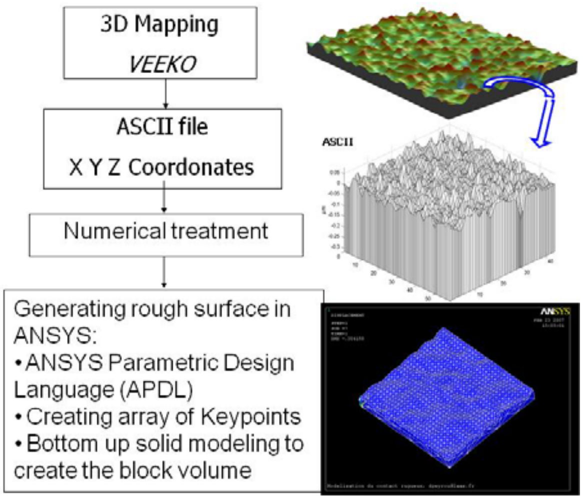
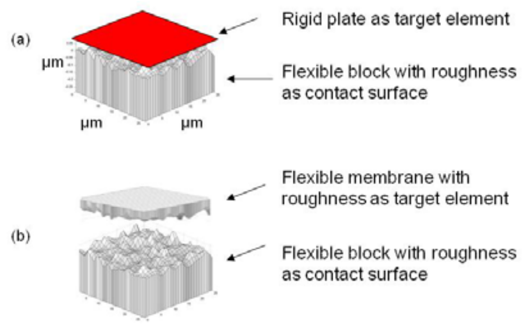


Figure 1: Reverse Engineering methodology



(c)

	Young modulus E	Poisson ratio ν	Yield stress	Tangent modulus
Au	80 GPa	0.42	300 MPa	10 GPa

Fig. 3: Model definition with a smooth, rigid target (a) and a rough flexible target (b). Material properties is described in table (c)

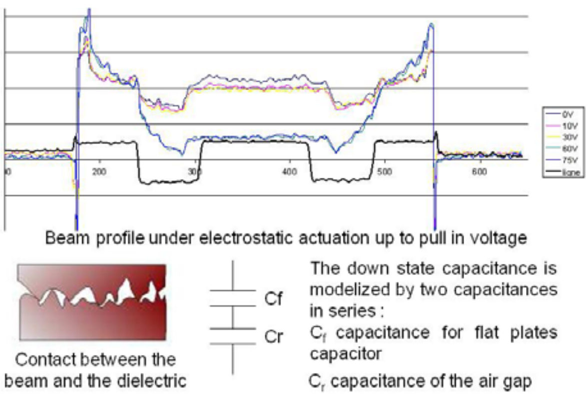


Figure 2: Analytical capacitive model

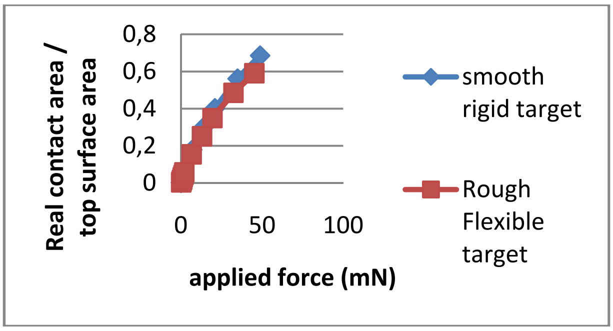


Figure 4 : Ratio between real contact area and apparent contact versus applied force

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