The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

TWO-SCALE ASYMPTOTIC HOMOGENIZATION IN A MEMS AUXETIC STRUCTURE FOR OVER ETCH IDENTIFICATION

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Key Words: *MEMS, auxetic, over etch, asymptotic homogenization.*

An innovative Micro-Electro-Mechanical Systems (MEMS) tunable mechanical filter has been recently proposed in [1]. It embeds a deformable structure made by a periodic repetition of an auxetic unit cell firstly proposed in [2] and four sets of electrodes placed on its sides within four frames. Thanks to the bandgap properties of the auxetic structure, the proposed MEMS acts as a mechanical filter in the MHz range, while tunability is achieved through the auxeticity of the chosen unit cell.

A first prototype has been fabricated through the ThELMA process of STMicroelectronics [3] and preliminary experimental results are available in the form of Capacitance-Voltage (C-V) curves [1]. To make a fair comparison between experimental results and numerical predictions and thus proving the right functioning of the proposed MEMS filter, a proper identification of fabrication imperfections that are inevitably present in micromachining processes, is necessary. Over etch, which is the deviation between the designed masks and the effective dimensions of the suspended parts, indeed strongly influences the performances of MEMS and is usually identified through visual inspection or through inverse identification using experimental data and finite element simulations. The first approach is usually too invasive especially if devices are encapsulated in vacuum and the package is not transparent. The second approach is instead viable but has huge computational costs especially if the geometry is complex and thin flexible elements, such as the auxetic unit cells of the proposed MEMS tunable filter, are present.

In this work, we replace in the finite element model the complex geometry of the auxetic unit cells with an equivalent homogeneous medium, whose linear-elastic effective properties are evaluated employing two-scale asymptotic homogenization [4]. Over etch is therefore identified by minimizing the relative error between experimental data and corresponding predictions obtained for different combinations of the fabrication imperfections. The proposed approach allows to significantly reduce computational times, thus representing an efficient tool to identify fabrication imperfections, such as over etch, in MEMS devices in almost real-time.

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