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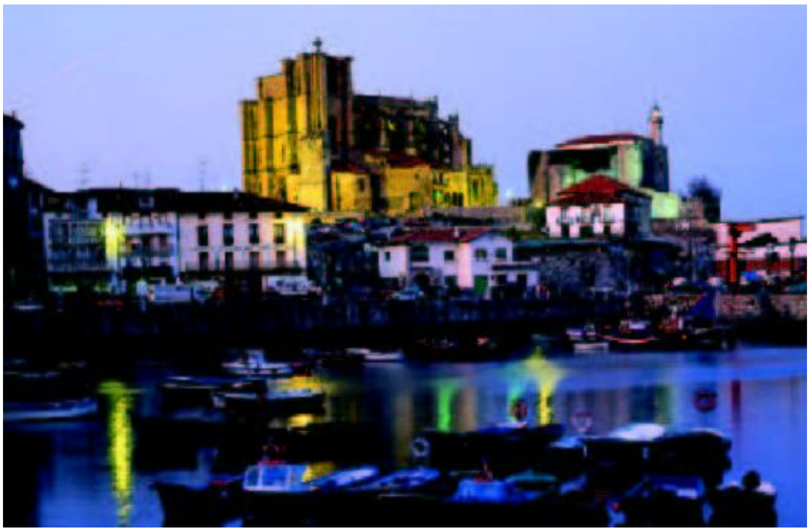

Views of Castro Urdiales, Spain

A semi-analytical procedure for the homogenisation of dielectric laminated composites at finite strains

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We focus on the layout optimisation of hierarchical laminated composites that can be profitably employed to enhance the actuation performance of electrostatically-activated soft dielectric transducers [1]. In particular, we study the behaviour of a rank-two laminate constituted by ideal dielectric phases obeying nonlinear elasticity. This actuation response is evaluated by coupling two rank-one problems: the first one is concerned with the two-phase microstructure constituting the so-called core; the second one, at the mesoscopic scale, involves the core and a third homogeneous phase. Concerning the microscale rank-one problem, we adopt for the core the analytical form of the effective free energy density obtained by Spinelli and Lopez-Pamies [2] for isochoric neo-Hookean elasticity. Hence, we solve the whole problem by imposing the macroscopic boundary prescriptions and the electro-mechanical continuity conditions at the laminate interfaces.
We analytically simplify at lowest terms the resulting set of nonlinear equations, thus obtaining a partly uncoupled system, which, as a main novelty with respect to the literature, is unaffected by the local Lagrangian multipliers ensuing from the assumed isochoric deformation. We demonstrate the computational efficiency of our procedure by studying two different composites previously investigated in [1, 3]. Moreover, on the basis of sensitivity analyses with respect to the micro- and meso-structural parameters, we provide new layouts able to optimise the actuation stretch.

References

[1] Tian, L., Tevet–Deree, L., deBotton, G. and Bhattacharya, K., Dielectric elastomer composites, J. Mech. Phys. Solids, 60, 181-198 (2012).
[2] Spinelli, S.A. and Lopez-Pamies, O., Some simple explicit results for the elastic dielectric properties and stability of layered composites, Int. J. Eng. Sci., 88, 15-28 (2015).
[3] Gei, M. and Mutasa, K.C.K., Optimisation of hierarchical dielectric elastomer laminated composites, Int. J. Nonlinear Mech., 106, 266-273 (2018).