Title of thesis: Caracterización micromecánica de compuestos con condiciones de contacto imperfecto en la interfase (Micromechanical characterization of composites with imperfect contact conditions at the interface)

Report: This thesis is about determination of the effective properties of piezoelectric composite materials with periodic microstructure, with parallelogram microscopic cells possessing imperfect contact conditions between the constituents of the composite. The method of asymptotic homogenization (MHA) for local problems is used to arrive at the homogenized equations and expressions that characterize the effective coefficients. The solution of such local problemson the microstructure takinginto account the property of imperfectcontact between the constituents of the composite, is a topic of high significance in the modelling and prediction of its electro-mechanical behaviour.

Many of the existing models, assume perfect contact between constituents, which is an ideal situation at the interface. Nevertheless, it is possible to have an area of imperfection owing to the existence of pores, or to chemical reactions between the constituent grains, among other interface anomalies.
In my overall assessment the thesis is well-written, very motivating to read and describes very significant scientific developments that will have a strong effect in the area of composite analysis and design.

Some Suggestions/Comments;

1. The thesis builds upon the knowledge about imperfect adhesion between the matrix and inclusions in many reinforced materials. Thus the consideration of perfect contact turns out to be really inadequate to describe the mechanical and physical characteristics of composites. I would suggest the author to cite more experimental evidence from literature supporting this at the Introduction of the thesis. Further discussionand literature survey in this regard could be included as well.

2. This is equally true about the comparison of some of the results with experiment. Perhaps as the author states, due to the inadequacy of the existing models in treating the interface accurately, such works (where perfect interface is assumed) would result in deviation of the theoretical values with experimental study. However, since the present work addresses the interface problem, the results derived from this work should have compared favourably with the experiments if any.

3. There would be local stresses developed at the interface due to the imperfections such as various kinds of dislocations and lattice mismatch because of the bonding of two materials of different lattice constants. This kind of an interface imperfection can lead to great modification of certain physical quantities especially the piezoelectric and

magnetoelectric effect especially when the composite phases are of small thickness. Is it possible that the present model can accommodate such imperfections? Could you comment on that under the light of your present treatment of the interface? I think this could be discussed in the introduction chapter.

4. On page 41, Eq. (1.16); shouldn't one havea dot product in the first equation viz., $\sigma^{(1)} \cdot n^{(1)} = K\|u\|$ which is written from Eq.(1.14)? Also by the definition of the *jump* or *contrast* of the variables given on page 38, a minus sign must appear in both of the equations Eq. (1.16).On page 47, the order of asymptotic expansion *q* is not mentioned in the discussion after Eq. (2.2).

5. It is interesting to see that (as depicted in Fig. 15), the important homogenized piezoelectric coefficients e^*_{322} and most importantly e^*_{333} are not affected by the interface imperfections. The author could discuss the physical significance of this result as well as the possible reasons for such behaviour, since e^*_{333} (or alternatively d^*_{333} the longitudinal piezoelectric strain coefficient) defines the piezoelectricity of a material.

6. Similarly as above the dielectric permittivity d^*_{33} does not suffer modification due to imperfect contact conditions (mechanical and electrical) as well.

Helder C. Rodrigues
Professor
Presidente do Departamento de Engenharia Mecânica Instituto Superior Tecnico
Av. Rovisco Pais
1049-001 Lisboa
Portugal
https://fenix.ist.utl.pt/departamentos/dem/