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Generalized electro-mechanical coupling with strain gradients and meshfree computations

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ABSTRACT

Materials exhibiting electro-mechanically coupled behaviour, such as electro-active polymers (EAP), belong to the group of so-called smart materials. In particular, EAP have the characteristic to undergo large deformations while sustaining correspondingly large electrical loading. This property can be utilized for actuators in electro-mechanical systems, artificial muscles and so forth. First efforts modelling EAP material can be found in [1][2].

In case of smaller structures however, it has been discovered in the realm of pure mechanics that classical theories and experimental results open a gap which can be bridged with so-called generalized continuum theories. Specifically, size-scale effects are here of interest. These kind of physical phenomena can be expected, if the size of the microscopic material constituents can not be considered to be negligible small anymore compared to the structure's overall dimensions. In this context generalized continuum formulations have been proven to account for the micro-structural influence to the macroscopic material response. Here, we want to adopt a generalized continuum framework [3][4] and extend it to also encompass the electro-mechanically coupled behaviour of EAP. The approach introduces not only new strain and stress measures but also a generalized electro-mechanically coupled variational principle. The formulation of the latter is straight forward, as the electro-mechanical coupling is thought to be an implicit part of the mechanical strain. The theory is completed by Dirichlet boundary conditions for the displacement field and its derivatives as well as the electric potential.

The proposed generalized continuum theory is based on the consideration of a micro- and a macro-space which together span the generalized space. Hereby, as important aspect must be emphasized that all quantities are defined in this generalized space such that the purely mechanical as well as the electro-mechanical constitutive law is naturally implemented in the generalized continuum. This fact bears the advantage that material information of the micro-space, which is here only its geometrical specifications, can automatically enter the constitutive law.

For modelling purposes it has been found that the combination with moving least square approximations provides the flexibility in terms of continuity and consistency required by this approach.

REFERENCES

[1] A. Dorfmann and R.W. Ogden. “Nonlinear electroelasticity”. *Acta Mechanica*, Vol. **174**, 167-183, 2005.

[2] D.K. Vu and P. Steinmann and G. Possart. “Numerical modelling of non-linear electroelasticity”. *International Journal for Numerical Methods in Engineering*, Vol. **70**, 685-704, 2007.

[3] C. Sansour. “A unified concept of elastic-viscoplastic Cosserat and micromorphic continua”. *Journal de Physique IV Proceedings*, Vol. **8**, 341-348, 1998.

[4] C. Sansour and S. Skatulla. “A higher gradient formulation and meshfree-based computation for elastic rock”. *Geomechanics and Geoengineering*, Vol. **2**, 3-15, 2007.