Silicone-based Dielectric Elastomers – DTU Orbit (09/06/2019)

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Efficient conversion of energy from one form to another (transduction) is an important topic in our daily life, and it is a necessity in moving away from the fossil-based society. Dielectric elastomers hold great promise as soft transducers, since they are compliant and lightweight amongst many favorable properties. Their transduction principle lies in direct conversion of electrical energy into mechanical energy or vice versa with no need for gearing and with no stand-by energy consumption. This should in principle support a more efficient use of energy, a hot topic in our current society where energy efficient solutions are highly sought. These properties allow for interesting products ranging very broadly, e.g. from eye implants over artificial skins over soft robotics to huge wave energy harvesting plants. All these products utilize the inherent softness and compliance of the dielectric elastomer transducers.

The subject of this thesis is improvement of properties of silicone-based dielectric elastomers with special focus on design guides towards electrically, mechanically, and electromechanically reliable elastomers. Strategies for improving dielectric elastomer performance are widely investigated but rarely discussed in the context of mechanical integrity and thus product reliability. Focus here is on long-term reliability of the dielectric elastomers and how to achieve this by means of careful elastomer design. This thesis presents methods and results of analyses acquired in the cross-disciplinary, collaborative effort on dielectric elastomers funded by Innovationsfonden Denmark (formerly Advanced Technology Foundation) with the materials workgroup headed by the author. Main contributors to the work have been research scientists at Danfoss PolyPower, colleagues from the Danish Polymer Centre, as well as 7 PhD students and 5 postdocs being involved in the project. International collaborators were also part of the project at various stages. The studies behind this thesis have been conducted over a period of about 5 years, and 10 selected papers describing the main results are included as appendices. They were chosen to represent the prime results obtained within the project. Most of the technical aspects discussed in this thesis are contained within these references. Several other important works have been omitted in the appendices in order to keep the thesis relatively short and concise.

Throughout the thesis the articles within the appendices are referred to as A1-A10. For all of these articles, the author was the principal investigator. Other dielectric-elastomer related papers by the author - either as a principal investigator or co-investigator- are referred to as A11-A51. Chapters 1 to 5 of the thesis present a coherent summary of the included papers in a common context, emphasizing the overall purpose and flow of the analysis thematically. Unpublished work is included as well to facilitate coupling between approaches as well as to provide the full, comprehensive story. Chapter 6 gives a conclusion, and in Chapter 7 a personal perspective on the future of dielectric elastomer research is given.

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