Development of a one-pot process for functionalization and cross-linking of polydimethylsiloxane (PDMS)

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INTRODUCTION

Novel green technologies delivering large quantities of energy are needed for a sustainable future. The dielectric electroactive polymer (DEAP) technology is one of such with the potential of becoming a disruptive technology within wave harvesting. For this to be realized polymer materials with better performances and especially with higher energy densities are required. This project aims at improving the energy density significantly.
For the material to the DEAP an elastomer is used, often PDMS. This elastomer is sandwiched between compliant electrodes, this system then becomes a capacitor. When a voltage is applied on the electrodes they will squeeze together because of electrostatic forces, and thereby the elastomer thickness will decrease because of the incompressibility (Figure 1).

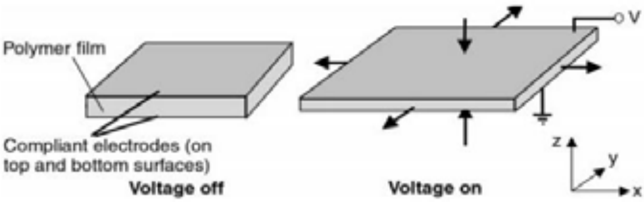

Figure 1 Working principle of DEAP. When the voltage is turned on the electrodes will squeeze together, the thickness will decrease and the area will increase

The incompressibility and the elasticity of the material are exploited. If the stretched DEAP film is charged with a voltage and then relaxed, the voltage will increase. For wave harvesting the waves are being used to the stretching of the films.

OPTIMIZATION OF THE PDMS FILM

The amount of energy is limited by the energy density of the material, which scales linearly with the dielectric permittivity. Therefore, to increase the energy production the dielectric permittivity can be increased. This can be done by adding dipoles to the PDMS network. The way this is done so far is in a two-step process that is not that industrially minded. Therefore, in this project the target is to develop a new one-pot process, where the functionalization and cross-linking of the PDMS are done in the same step. The commercial network XLR630is used due to its good mechanical properties.
It has been possible to increase the dielectric permittivity from 2.9 to 3.74 at 100 Hz, with tan δ at $6.32*10^{-3}$, for a film with 50 w% of the commercial network. That leads to an increase of the energy that can be processed with 29 %. To make the films stronger, it is possible to make thin films, silica particles have been added. For this film the electrical breakdown was measured to 72.7 V/µm. The reproduction for this procedure was unstable, because the films broke, because the adding of the silica particles make the network weaker. It can then be concluded that it is possible to make the films in a one-step process, but the conditions in the amount of the chemicals and temperature have to be more controlled.