# Principle and Performance of a Novel Soft Material Loudspeaker

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The revolution in virtual reality (VR) technology requires alternatives to conventional bulky electromagnetic loudspeakers using voice coil or rigid electrostatic loudspeakers for more realistic and immersive viewing and listening environment. Due to the attractive attributions in shape conformability, fast response, light weight and low cost, dielectric elastomers have received considerable interest in the development of low-profile electroactive polymer film (EAP) loudspeakers, which can be surface-mounted in VR equipment, rooms with 22.2 multichannel sound system or vehicle interiors, and massively used in active noise control. Since the sound field is generated by the out-of-plane deformation of radiation surface, an air chamber with positive or negative pressure, or mechanical bias are always required in dielectric elastomer loudspeakers to convert the electric-induced large in-plane deformation to the out-of-plane format. Until recently, a real flat loudspeaker with 1.2mm thickness is proposed using a polyacrylic elastomer film (VHB4905, 3M corporation) sandwiched between two complaint ionic gel electrode layer. In this paper, the working principle of this loudspeaker is proposed by analyzing the electro-mechanical coupled dynamic model for a pre-stretched dielectric elastomer derived from the free energy theory. The conversion of in-plane oscillation to out-of-plane oscillation is experimentally verified by dielectric elastomer loudspeakers with carbon grease electrodes under different offset and alternating voltage ratios. The viscosity of VHB4905 which is not included in the dynamic model has non-neglectable influence on the vibration of radiating surface. Finally, the generated acoustic pressure and harmonic distortion of a dielectric loudspeaker with transparent ionic gel electrodes were characterized in a standing wave tube within frequency band 50-2000 Hz(much below the cutoff frequency). Besides the fundamental response and super harmonic, it is interesting to find sub-harmonic response appears and dominates the radiated sound field under certain excitation parameter (frequency, offset and alternating voltage amplitude). This unique characteristic may be exploited in frequency tuning system.