Development of a Reconfigurable MRI Coil using Electrostrictive Polymer Artificial Muscle Actuators

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Introduction: A trade-off in image quality exists between depth of penetration of a surface coil and peak signal to noise ratio (SNR) as a function of coil dimensions. To optimize filling factor, and therefore image quality, at a given distance from the coil, the appropriate coil dimensions should be selected. Smaller coils offer higher SNR for superficial regions of interest, whereas larger coils are better suited for imaging of deeper regions of interest (1)

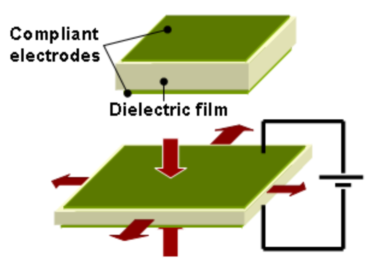
An MRI compatible actuator technology, Electrostrictive Polymer Artificial Muscles (EPAM), enables coils to be resized or moved with respect to the sample. We have chosen this coil application to demonstrate the utility of this technology due to the rigorous demands of MRI compatibility necessary to make an image free of artifact. Other applications such as manipulators for MRI-guided interventions (2,3) are also possible.

Methods: The EPAM actuator is comprised of a layer of dielectric elastomeric film surrounded by layers of compliant carbon grease electrodes. When the electrodes are electrostatically charged (ON state), they attract one another, causing the film to laterally strain (Fig. 1). The EPAM was placed in a rigid frame with flexible joints, allowing the unit to do work (4). Two actuators were cascaded to achieve of stroke of 2.5". The actuators were attached to a "trombone" MRI coil, constructed of telescoping concentric copper tubes (5), with initial length of 3" and final length 5.5". Varacter diodes were biased to retuned the coil (6) after discrete resizing.

Results: EPAM technology has been shown to be MRI compatible (Fig 3a). The images were affected by coil resizing as expect (Fig 3b-3c). The susceptibility artifacts were caused by varacter diodes, the not EPAM element.

Discussion: The MRI compatibility of EPAM technology has been demonstrated with the most demanding application- MRI coils. EPAMS offer a robust method for adapting the effective field of view of an MRI coil without complex electronic hardware. The method can be extended to surface coils with multiple resizable axes, birdcage coils with variable length, or phased array coils with resizable elements. Since the coil can have only discrete states of size, varacter tuning can be applied without a feedback method. Such a phased array coil can be optimized to the patient habitus or provide flexibility in optimizing sensitivity profiles for parallel imaging. Future developments involve the use of all-plastic manipulators for surgical assist robots within the confines of open or closed MRI scanners.

Fig 1: Actuation pressure acting on polymer film in the OFF state (above) and the ON state (below).



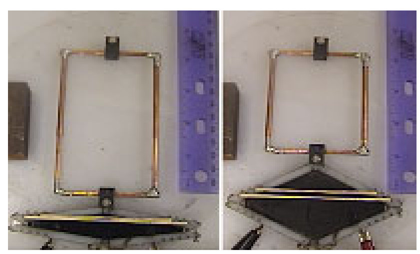


Fig 2: Resizable trombone coil (frame only) with a single EPAM in both the OFF and

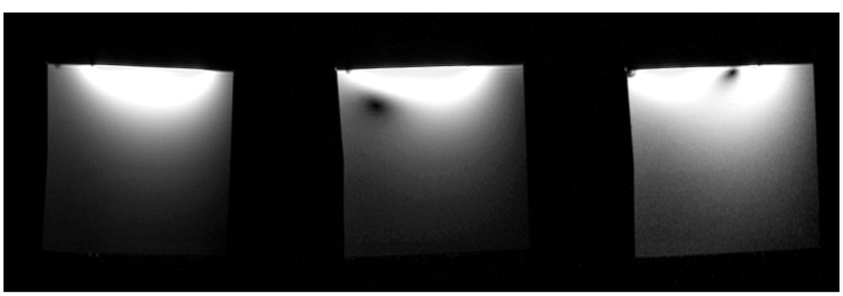


Fig 3: RF noise free image acquired with (a) GE coil while EPAM coil was activated, (b) EPAM coil with minimum diameter (ON) and (c) EPAM coil with maximum diameter (OFF).

References:

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