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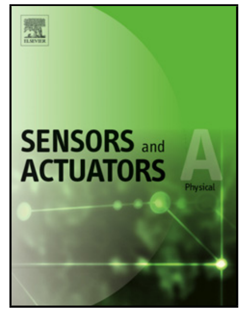

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Wireless deep-subwavelength metamaterial enabling sub-mm resolution magnetic resonance imaging

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Highlights

- Wireless metamaterial architecture is proposed, modeled and demonstrated.
- New geometry allows for high Q-factor and compactness, simultaneously.
- Frequency range includes various wireless applications such as sub-mm resolution MRI.
- Exhibiting high-Q, despite tissue loading is preserved.

Abstract

A wireless deep-subwavelength metamaterial architecture is proposed, modeled and demonstrated for a high-resolution magnetic resonance imaging (HR-MRI) application that is miniaturized to be resonant at approximately $\lambda_0/1500$ dimensions. The proposed structure has the adjustable resonance frequency from 65 MHz to 5.5 GHz for the sub-cm footprint area (8 mm × 8 mm for this study) and provides a quality factor (Q-factor) of approximately 80 in free space for 123 MHz of operation. This structure consists of a cross-via metallized partial-double-layer metamaterial, sandwiching a dielectric thin film; this structure strongly localizes the electric field in this film and has a highly capacitive metal overlay that allows for a wide range of frequency adjustment. Although the achieved resonance frequencies enable a large number of applications, as a proof-of-concept demonstration, we experimentally showed the operation of this wireless metastructure in HR-MRI to highlight its precise frequency adjustment and signal-to-noise-ratio (SNR) improvement capabilities. The proposed metamaterial was found to maintains high Q-factors despite loading with a body-mimicking lossy phantom. The experimental results indicated that the proposed metastructure can be used as an SNR-enhancing device offering 15-fold SNR enhancements that allows for imaging of objects as small as 200 μm in diameter in its vicinity,