Metamaterial cell for B1+ field manipulation at 9.4T MRI

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Introduction: Metamaterials (MM) are artificial materials that can be used in MRI to manipulate electromagnetic fields[1]. In this abstract, we present one cell MM which alters B1+ field pattern when placed between RF transmit antenna and phantom. We show measured results of B1+ field when RF transmit antennas are box monopole and small loop antenna.

Methods: In Fig. 1 geometry of one MM cell is presented (dimensions are in mm). Design of the cell structure is as reported in[2] and adapted for 400MHz frequency. Proposed structure consists of 8mm thick teflon plate. One short and two continuous copper strips are placed on both sides of the plate. Measurement setup is shown in Fig. 2. MM plate is placed between RF excitation antenna and phantom, closer to the phantom's head. Two antennas are used as RF excitation sources – box shaped monopole antenna[3] and small loop antenna. B1+ field maps are measured on head and shoulder phantom in 9.4T whole body scanner (Siemens Healthcare, Erlangen, Germany). Box antenna was placed at 300mm and loop antenna was placed at 140mm distance from the phantom's head. Small loop antenna is placed in the plane perpendicular to the axis of the bore cylinder.

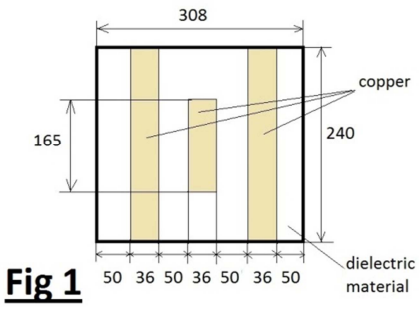

Fig 1

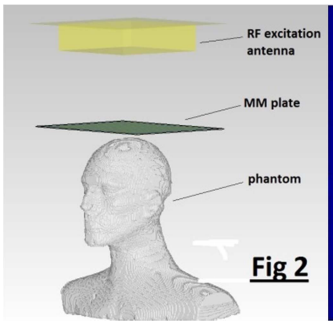

Fig 2

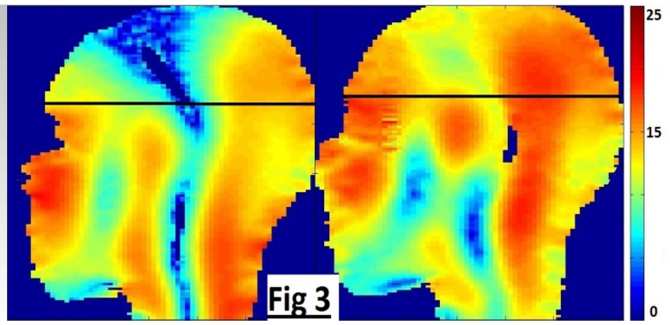

Fig 3

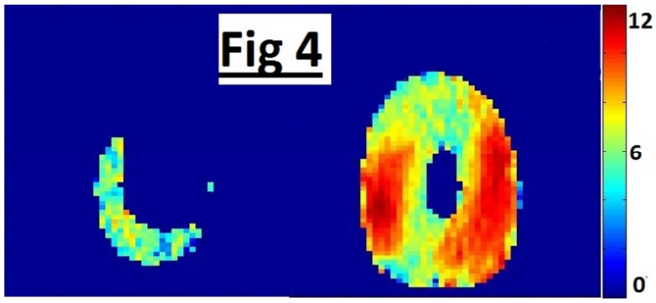

Fig 4

Results: Figs. 3 and 4 show measured B1+ maps in nT/V. Fig. 3 shows results produced with box monopole antenna. Mean field in the upper brain region (above black line) was calculated for the case with (Fig. 3, right) and without MM plate (Fig. 3, left) placed between phantom and box antenna. The calculated increase in mean field in marked region is over 100%. Fig. 4 shows B1+ distribution on the transversal slice when small loop antenna is used as RF excitation source. No B1+ field could be produced with the small loop alone (Fig. 4, left), while it is possible if MM cell is placed between coil and phantom (Fig. 4, right).

Conclusions: In this abstract, we have presented MM cell designed to enhance B1+field when placed between phantom and RF source at 9.4T MRI. We have demonstrated significant effect on B1+ field when box and small loop antennas are used as RF excitation sources. Future work would include design of smaller MM cells which size is comparable to that of loop antennas so they can be placed between subject and individual loop in transmit/receive loop arrays. Also, design of smaller MM cells in array configuration is intended which should provide stronger field enhancement then with single MM cell.

References: [1] Wiltshire M C K et al., Sci. 291:849-851, 2001. [2] Zhou J et al., Phys. Rev. B, 73:041101, 2006. [3] Zivkovic I and Scheffler K, 30th Ann. Sci. Meet. ESMRMB 2013, Magn. Res. Mat. Phys. Bio. Med, 26(1):189-190, 2013.