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Localization and enhancement of cavitation and heating during HIFU exposure using microparticles of high surface roughness

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The occurrence of cavitation during HIFU exposure is associated with higher heating rates than in the absence of bubble activity. However, the peak rarefaction pressures required to initiate cavitation in vivo are high (7-10 MPa), making it difficult to localize, sustain and confine cavitation activity and its associated bioeffects. In this work, we explore the use of rough microparticles to promote and localize cavitation nucleation during HIFU exposures. Polystyrene microparticles of mean diameter $\sim$2 μm are embedded in a polyacrylamide tissue mimicking phantom, which has a high cavitation threshold similar to tissue. The temperature rise during HIFU exposure is measured using an embedded needle thermocouple, whilst cavitation activity is simultaneously monitored using a passive cavitation detector (PCD). The presence of particles is shown to lower the cavitation threshold significantly and, above this threshold, to result in higher heating rates than in the absence of particles for the same focal intensity. Furthermore, it is found that particles make it possible to repeatedly initiate cavitation at the same location and lead to increased broadband noise emissions. Finally, a strong correlation is found between enhanced heating and the broadband emissions arising from inertial cavitation.