Purpose: In the current standard-of-care treatments for breast cancer, there remains a need for the reduction of local recurrence, harmful side effects, and cosmetic harm. high-intensity focused ultrasound (HIFU) is generally effective but slow for large target areas and requires precise guidance. A combined microwave/ultrasound transcutaneous thermal therapy system is being developed for fast targeted or targeted plus diffuse treatment of breast cancer.

Methods: In the microwave component, a cylindrical array of antennas operating at 915 MHz is used to focus continuous-wave microwave energy transcutaneously into the pendent breast suspended in a coupling medium. The compatible HIFU system consists of two half shell arrays (Imasonic, Inc., Besancon, France) that allow close approach to the chest wall. In each case, prior studies provide breast tissue properties and distributions, for incorporation into multiphysics models. Time- reversal techniques are employed to find a solution (relative amplitudes and phase) for microwave focusing at a given location, and to precondition a weighted inverse solver that can optimize treatment planning for ablation at the tumor location while minimizing thermal dose elsewhere in the breast.

Results: A full-wave forward model of the microwave therapy array has been created and breast phantoms (E. Zastrow, http://uwcem.ece.wisc.edu/MRIdatabase/) imported. Coupling of the electromagnetic energy deposition to the bioheat equation has been achieved using COMSOL Multiphysics, and a temperature map within the breast accounting for perfusion effects has been modeled. Studies of time-reversal focusing results have shown that therapeutic levels of heat deposition with good targeting accuracy can be achieved using a twelve element array. Ultrasound beam patterns are close to predictions. Initial study of coupling agents compatible with both fields and with shared apertures is promising.

Conclusions: Based on these encouraging results, the design and fabrication of adaptively focused combined laboratory systems are proceeding.

Supported in part by DOD/BCRP W81XWH-10-1-0730.