A Time- and Temperature-Stable Complex Breast Phantom for Microwave Breast Imaging

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Microwave imaging has been proposed for breast imaging. At the University of Calgary, a tissue sensing adaptive radar (TSAR) system is being developed [J. Bourqui, J. Sill and E. Fear, *Int Jour Biomedical Imaging,* 12 pages, 2012]. This system uses the reflections of microwaves from different tissue types to create images related to the electromagnetic properties, which are then used to identify anomalies that may correspond to tumors. To test this system, physical breast models with similar dielectric properties to human breasts are required. These phantoms are difficult to create due to the relatively high dielectric properties of human tissue, the complex inner structure of the breast and the need to position the phantom within the scanner. One popular method of creating breast phantoms is using gelatin mixtures (e.g. [M. Lazebnik et al., *Phys Med Biol*, 52, pg. 6093-6115, 2007]). These mixtures can create highly-accurate breast phantoms; however, the gelatin mixtures lack physical robustness, they need to be cooled and ultimately they will breakdown over time. There is a need for a new approach to create phantoms that will have similar dielectric properties to the breast, will have complex inner structures, and yet will not decay over time.

To create the tissue-mimicking material, we propose using mixtures of graphite, carbon-black and silicone rubber [C. Gabriel, *Phys Med Biol,* 52, pg. 4205-4210, 2007]. These materials will not decay over time and do not require cooling. Also, by changing the concentration of carbon black and graphite, a wide variety of tissue properties may be created. These mixtures exhibit similar properties to human tissue over frequencies from 1 to 10 GHz. To create these tissues, the three components are weighed, mixed and then allowed to cure for 8 hours. This is significantly easier than the gelatin mixtures which require heating, cooling and many more ingredients. The final product is very strong which allows for very thin skin-like layers to be created in addition to the inner structure.

To create the inner structure of the breast, a mould of the fatty tissue is created from a plastic material. Typically, the fatty tissue surrounds the glandular tissue in the center of the breast; therefore, the fatty tissue can be printed with a cavity in the center for the glandular tissue, and the glandular tissue, which is made from the graphite/carbon black/silicone rubber mixture, can be poured into this cavity before the silicone rubber sets.

The final product is a complex breast phantom that is not expected to break down for many years despite changes in temperature, humidity, etc. This phantom therefore allows the user to test their system repeatedly with the same breast phantom over time. Our phantom also has a skin layer, which is unique to our method and useful for testing skin subtraction algorithms.