A Study of Multi-Tapered X-ray Capillary Optics for Mammography

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X-ray mammography is currently the primary tool used for breast cancer detection. However mammography has limitations. Studies have shown that 5%-15% of breast cancers are not visualized mammographically and of the number of cases sent to biopsy, only 15% are actually cancerous (high false positive percentage).

The long term goal of this project is to improve the x-ray mammographic imaging system using capillary optics. A post-patient capillary optic lens has the potential to increase spatial resolution and eliminate the detection of scattered x-rays, thereby improving image contrast and SNR. These improvements can be exploited with any detector but may have the greatest potential when implemented with digital detectors.

An image analysis study has been performed using a prototype multi-tapered optic to determine the feasibility of a full-field multi-tapered optic. Scatter fraction, contrast, transmission, uniformity, MTF, NPS and DQE were measured for a CR imaging system when the prototype multi-tapered optic lens was applied. The results were compared with standard grid and air gap techniques.

The measurements demonstrate that the multi-tapered optic lens removes 85% of the scattered photons, while air gap and grid methods remove 66% and 39%, respectively. This results in an improvement of contrast by approximately 80% for the optics, compared to 51% for the air gap and 30% for the grid methods. The single capillary optic lenses can improve the limiting resolution (5% MTF level) of the CR detector by 78% due to magnification with very little focal spot blurring, while the multi-tapered prototype improved resolution significantly but not as much as the single optic. This was due to relative misalignment of the individual lenses in the multi-tapered optic. Acceptable levels of misalignment have been established that appear to be readily achievable. Once this relative misalignment issue is resolved, the multi-tapered lens will produce results similar to single optics.

These measurements have shown that it is feasible to create a multi-tapered optic lens that significantly improves system DQE by improving system MTF and virtually eliminating scatter. With continued improvements in transmission and relative alignment, a full-field multi-tapered lens will be feasible.