Chapter 6

Conclusions

This work has presented an approach to the problem of building a millimeter wave imaging array antenna which is relatively simple and has the potential of solving a number of problems. We have found that good beam patterns, practical feed networks, input impedance matching, and reasonably good efficiency can all be achieved. At the same time it is also possibile to circumvent the difficulty of having to work with extremely thin substrates which are difficult to process and handle.

The use of twin slot antennas in conjunction with a layered dielectric substrate provides a means of addressing all of these problems. The disadvantage of this approach is that it produces inherently narrow band antenna, although this is not always an important disadvantage. In Chapter 3, it was shown that broadside spaced twin elements, both slots and dipoles, could in certain cases reduce the power coupled to trapped waves in the substrate. When layered substrates were used in many moderate gain structures, the dielectric absorption losses and the losses in the ground plane due to finite conductivity were small. However, when more layers and a more strongly resonant dielectric stack were used, these losses became more important as discussed in Chapter 4. It appears the even with low loss dielectrics, a superconducting ground plane would be required for very high gain structures.

There is no "better" antenna, when considering slots or dipoles. When a low density ($\varepsilon_r = 4$) substrate was used in the "inverted" dielectric structure discussed in Chapter 4, the dipole radiator was more efficient than the slot, or even twin slot antennas. When a high density substrate such as GaAs ($\varepsilon_r = 13$) was used in the "symmetric" structure, broadside-spaced twin slots were more efficient than the broadside-spaced twin dipoles. Each type of element has its advantages. The twin slot configuration was particularly easy to feed with a microstrip line. The slots could be electromagnetically coupled to a microstrip line as was discussed in Chapters 2 and 5. The length of the feed line between the twin slots can be adjusted to obtain the desired impedance. In contrast to slots, dipoles would be much more difficult to feed even though dipoles were more efficient radiators-to-air on several of the structures considered.

Most of the imaging arrays built to date have used either dipoles or a variation of the dipole antennas [1,4,5,6,44]. This work has proposed that under certain circumstances, twin slot antennas could provide a practical antenna structure that could be used in two-dimensional imaging arrays. In some cases [1, 44] twin dipole elements constructed on substrates less than a quarter of a wavelength thick have been used as imaging array elements presumably because their pattern is more symmetric than the single dipole element although little explanantion was given about the choice of antenna structure or parameters. In these cases considered [1, 44], the design of the feedline to the antenna proved to be a difficult problem to overcome. Although the slot feed network design will still be difficult for a two dimensional array, the network will be isolated from the side of the antennas receiving the radiation from the optical system.

Perhaps an interesting combination would be to excite a slot antenna with a microstrip feed line, and then employ a dipole sandwiched between layers 1 and 2 of the dielectric [45]. The dipole would act as a parasitic element and re-radiate more efficiently to air. Since the dipole does not couple as strongly to the guided waves the efficiency of the antenna could be improved. There will be some difficulties with this scheme because the dipole must be oriented perpendicular to the slot, and the fields radiated by the slot will not be a good "match" to excite currents in the dipole. One possible configuration that might be an improvement would be to use twin slots feeding a twin parasitic dipole. This configuration would have some similarity to the aperture-coupled patch antenna proposed by D.M. Pozar [39]. The main difference is that the dielectric of layer 1 between the ground plane and the dipole is electrically thick, while for the patch antenna the dielectric layer must be thin.

The next step in this work would be to explore the cross-talk problems between the pairs of slots, and to construct a one-dimensional array of these elements. The realization of a two dimensional imaging array may have to wait until some type of matrix-addressable detector could be used to detect the antenna signal.

In conclusion, we have outlined some of the important considerations for fabricating millimeter wave and FIR antennas on electrically thick dielectric substrates. This scheme will hopefully provide a useful alternative that could be used where substrate lens arrays or membrane supported arrays would be difficult to employ.