Reflectarray antennas uniquely combine the advantages of parabolic reflectors and phased array antennas. Comprised of planar structures similar to phased arrays and utilizing quasi-optical excitation similar to parabolic reflectors, reflectarray antennas provide beam steering without the need of complex and lossy feed networks. Chapter 1 discusses the basic theory of reflectarray and its design. A brief summary of previous work and current research status is presented. The inherent advantages and drawbacks of the reflectarray are discussed.

In chapter 2, a novel theoretical approach to extract the reflection coefficient of reflectarray unit cells is developed. The approach is applied to single-resonance unit cell elements under normal and waveguide incidences. The developed theory is also utilized to understand the difference between the TEM and TE10 mode of excitation. Using this theory, effects of different physical parameters on reflection properties of unit cells are studied without the need of full-wave simulations. Detailed analysis is performed for Ka-band reflectarray unit cells and verified by full-wave simulations. In addition, an approach to extract the Q factors using full-wave simulations is also presented. Lastly, a detailed study on the effects of inter-element spacing is also shown.

Q factor theory discussed in chapter 2 is extended to account for the varying incidence angles and polarizations in chapter 3. Emphasis is laid on elements located on planes where extremities in performance tend to occur. Anomalous phase characteristics are observed for particular polarization and incidence angles. The antenna element properties are assessed in terms of maximum reflection loss and slope of the reflection phase. A thorough analysis is performed at Ka band and the results obtained are verified using full-wave simulations. Reflection coefficients over a 749-element reflectarray aperture for a broadside radiation pattern are presented for a couple of cases and the effects of coupling conditions in conjunction with incidence angles are demonstrated. The presented theory provides explicit physical intuition and guidelines for efficient and accurate reflectarray design.

In chapter 4, tunable reflectarray elements capacitively loaded with Barium Strontium Titanate (BST) thin film are shown. First, the effects of substrate thickness are shown utilizing coupling conditions and the performance is optimized. To ensure minimum affects from biasing, optimized biasing schemes are discussed. The proposed unit cells are fabricated and measured, demonstrating the re-configurability by varying the applied E-field.

A reflectarray prototype utilizing the unit cell proposed in chapter 4 is designed, fabricated and measured in chapter 5. A 45 element array prototype is designed to demonstrate the beam-scanning capabilities. By varying the bias voltage across the array a beam scan up to 25o is demonstrated.

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The public is welcome to attend.