Patterned Ferroelectric Films for Tunable Microwave Devices

Microwave performance is enhanced by appropriate patterning.

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Tunable microwave devices based on metal terminals connected by thin ferroelectric films (see Figure 1) can be made to perform better by patterning the films to include suitably dimensioned, positioned, and oriented constrictions. The patterns (see Figure 2) can be formed during fabrication by means of selective etching processes.

The following observations regarding prior ferroelectric-based microwave devices and circuits constitute part of the background and impetus for the present patterning concept:

- The basic principle of design and operation of a ferroelectric-based microwave device calls for a continuous film of ferroelectric material that extends from one metal terminal to another on a low-loss dielectric substrate.
- The performances of conventional ferroelectric-based devices and circuits can be degraded by excessive losses and spurious resonances.
- Designers often seek to obtain linear tuning-versus-bias-voltage profiles. In general, the tuning-versus-bias voltage profile of such a device is difficult to control in the absence of suitable patterning. The desired linear profiles (more specifically, changes in frequency or phase proportional to changes in bias voltage) have not been observed.
- Ferroelectric materials are intrinsically lossy, and losses are especially pronounced in ferroelectric-based narrow-band filters, in which resonant elements must be separated by large distances to obtain the necessary isolation. In a typical prior ferroelectric-based device, the electric field is distributed uniformly across the unpatterned ferroelectric film; hence, if such a film is part of a narrow-band filter, spanning the required large distance, and the loss can be unacceptably high.

- Heretofore, the high permittivities of ferroelectric materials have given rise to large capacitances that have been detrimental to performance at microwave frequencies.

If the width of the ferroelectric film in such a device is reduced at one or more locations, then both the microwave field and any applied DC bias (tuning) electric field become concentrated at

![Figure 1. A Tunable Microwave Device is exemplified here as a one-pole microstrip filter with etched ferroelectric layer.](https://ntrs.nasa.gov/search.jsp?R=20090020611)

![Figure 2. A Coupled Section of the Filter shows etched ferroelectric layer.](https://ntrs.nasa.gov/search.jsp?R=20090020611)
Micron-Accurate Laser Fresnel-Diffraction Ranging System

This system would exploit the variation of Fresnel diffraction with distance.

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The figure schematically depicts two versions of an optoelectronic system, undergoing development at the time of reporting the information for this article, that is expected to be capable of measuring a distance between 2 and 10 m with an error of no more than 1 µm. The system would be designed to exploit Fresnel diffraction of a laser beam. In particular, it would be designed to take advantage of the fact that a Fresnel diffraction pattern is ultrasensitive to distance.

In either version, a Fresnel diffraction pattern would be generated by aiming a laser beam at a pinhole, the size of which could be varied. The diffracted laser light would illuminate the object, the distance to which was to be measured. The diffracted laser light reflected from that object would be collected by an optical receiver comprising a telescope equipped with an imaging photodetector array at its focal plane. The resulting Fresnel-diffraction-pattern readout from the array would be digitized and sent to a computer. In principle, the digitized Fresnel diffraction pattern could be compared computationally with a set of known Fresnel diffraction patterns for known distances. Once a match was found, the distance of the observed Fresnel pattern would be determined to within a micron. The range of the system would be limited only by the power of the laser, the maximum laser power tolerated by the optical train of the system, and the sensitivity of the photodetector array.

The two versions would differ in the following respects:

- In version 1, the focus of the telescope would be in the Fresnel region, and the telescope would have a small depth of focus. As a consequence, the Fresnel pattern would be imaged directly onto the photodetector array.

- In version 2, a multielement lens module would displace the Fresnel region from the vicinity of the pinhole to the vicinity of the optical receiver. As the distance to be measured varied, the location of the receiver relative to the displaced Fresnel-diffraction region would be determined by, in effect, inverting the known dependence of the diffraction pattern upon the distance.