crostrip feedline while maintaining a desirably large front-to-back lobe ratio.

This work was done by Ronald Pogorzelski and Jaikrishna Venkatesan of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-41791, volume and number of this NASA Tech Briefs *issue, and the page number.*

Patterned Ferroelectric Films for Tunable Microwave Devices

Microwave performance is enhanced by appropriate patterning.

John H. Glenn Research Center, Cleveland, Ohio

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

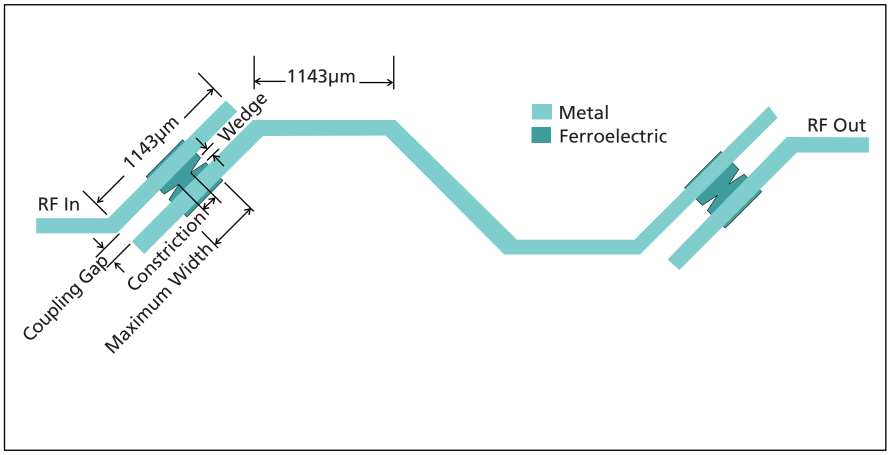


Figure 1. A **Tunable Microwave Device** is exemplified here as a one-pole microstrip filter with etched ferroelectric layer.

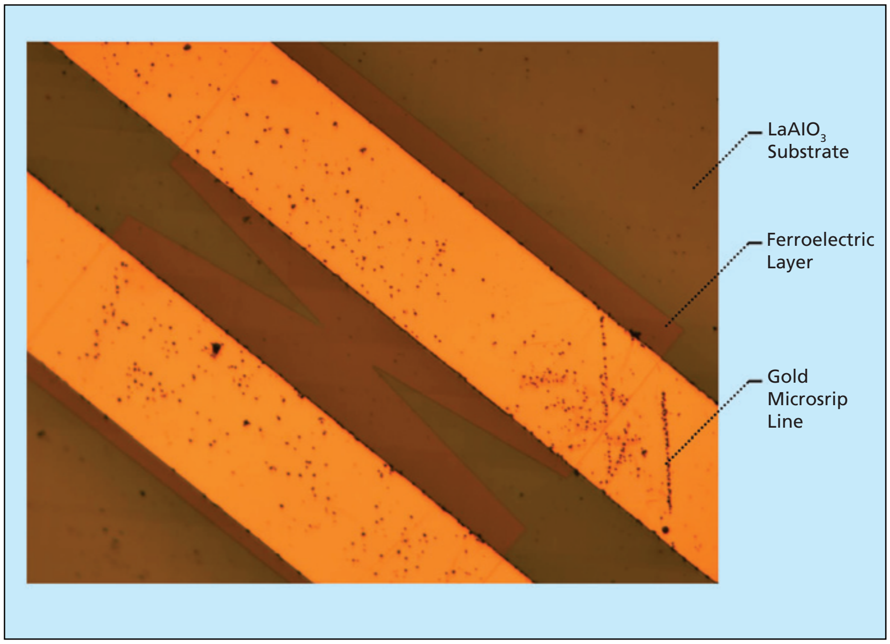


Figure 2. A **Coupled Section of the Filter** shows etched ferroelectric layer.

those locations. The magnitudes of both the permittivity and the dielectric loss of a ferroelectric material are reduced by application of a DC field. Because the concentration of the DC field in the constriction(s) magnifies the permittivity- and loss-reducing effects of the applied DC voltage, the permittivity and dielectric loss in the constriction(s) are smaller in the constriction(s) than they are in the wider parts of the ferroelectric film. Furthermore, inasmuch as displacement current must flow through either the constriction(s) or the low-loss dielectric substrate, the net effect of the constriction(s) is equivalent to that of incorporating one or more low-loss, low-permittivity region(s) in series with the high-loss, high-permittivity regions. In a series circuit, the properties of the low-capacitance series element (in this case, the constriction) dominate the overall performance. Concomitantly, the capacitance between the metal terminals is reduced.

By making the capacitance between the metal terminals small but tunable, a constriction increases the upper limit of the frequency range amenable to ferroelectric tuning. The present patterning concept is expected to be most advantageous for devices and circuits that must operate at frequencies from about 4 to about 60 GHz. A constriction can be designed such that the magnitude of the microwave electric field and the effective width of the region occupied by the microwave electric field become functions of the applied DC electric field, so that tunability is enhanced. It should even be possible to design the constriction to obtain a specific tuning-versus-voltage profile.

This work was done by Félix A. Miranda of Glenn Research Center and Carl H. Mueller of Analex Corp. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17411.

Micron-Accurate Laser Fresnel-Diffraction Ranging System

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

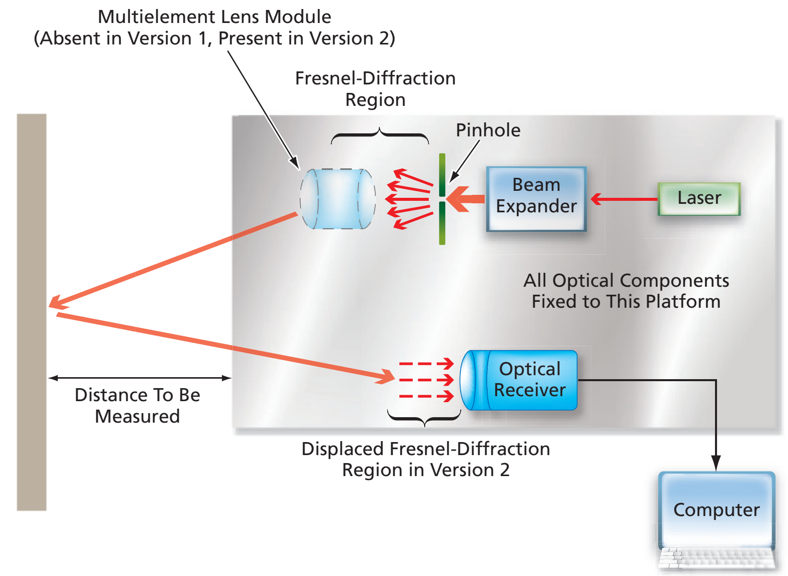
Marshall Space Flight Center, Alabama

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



An **Object Would Be Illuminated** with a Fresnel-diffracted laser beam. The distance to the object would be determined by, in effect, inverting the known dependence of the diffraction pattern upon the distance.