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Reconfigurable Array Antenna Using Microelectromechanical Systems (MEMS) Actuators

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RECONFIGURABLE ARRAY ANTENNA USING MICROELECTROMECHANICAL SYSTEMS (MEMS) ACTUATORS

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Abstract: The paper demonstrates a patch antenna integrated with a novel microelectromechanical systems (MEMS) actuator for reconfiguring the operating frequency. Experimental results demonstrate that the center frequency can be reconfigured by as much as 1.6 percent of the nominal operating frequency at K-Band. In addition, a novel on-wafer antenna pattern measurement technique is demonstrated.

I. INTRODUCTION

Recently there has been tremendous interest in planar antennas capable of dynamically reconfiguring the radiation pattern to provide horizon-to-horizon scan coverage over a wide frequency range, through geometric reconfiguration [1]. These capabilities are possible through the use of microelectromechanical systems (MEMS) based switching and actuating devices or circuits. The MEMS devices offer the following advantages over semiconductor devices first, significant reduction in insertion loss. Second, they consume insignificant amount of power during operation. Third, higher linearity hence lower signal distortion. Typical examples of MEMS based antennas are reported in [2], [3], and [4].

In this paper, we present a new frequency reconfigurable patch antenna via use of integrated microelectromechanical systems (MEMS) actuators. The key features of this approach is, that it does not increase the antenna element dimensions, thus allowing for use in planar phased arrays. Second, each actuator requires only a single bias line for control, which implies greatly simplified construction and operation. In addition, the paper also demonstrates a novel on-wafer pattern measurement technique. The advantage of this technique is that there is no need to dice and separate the individual antennas on the wafer, thus resulting in tremendous savings in cost and time.

II. MEMS ACTUATOR DESIGN AND FABRICATION

A Patch antenna with two independent MEMS actuators is illustrated in Fig. 1. The antenna is fabricated on high resistivity silicon wafer ($\epsilon_r = 11.7$, $h = 400\mu m$) with spin-on-glass (SOG) ($\epsilon_{r1} = 3.1$, $h_1 \approx 1.5\mu m$) as the dielectric support layer. Each actuator consists of a moveable metal overpass suspended over a metal stub and supported at either ends by metalized vias which are electrically connected to the patch antenna. The metal strip of length L and width W attached to the metal stub behaves as a parallel plate capacitor. The patch antenna operates at its nominal frequency as determined by the dimension b when the actuator is in the OFF state. The actuator is in the ON state when the overpass is pulled down by the electrostatic force due to the bias, and the capacitance of the metal strip appears in shunt with the input impedance of the patch antenna. This capacitance tunes the patch to a lower operating frequency.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

The measured return loss for the two states of the actuators are shown in Fig. 2. When both the actuators are in the OFF state, the patch resonates at its nominal operating frequency (f_0) of about 25.0 GHz. When both actuators are in the ON state, the f_{ON} is 24.6 GHz. The 400 MHz shift is about 1.6 percent of f_0. To measure the E- and H-plane radiation patterns of the patch antenna, the RF probe station is modified to accommodate a small horn antenna. The horn antenna is attached to a Plexiglas™ fixture and is driven along an arc by a stepper motor. Thus the horn can measure the relative field intensity of the patch as a function of the angle from boresight. The experimental setup is shown in Fig. 3. The measured E- and H-plane radiation patterns are shown in Fig. 4. At the present time, these actuators are being integrated into a 2×2 patch antenna array shown in Fig. 5. The array characteristics will be presented at the symposium.

IV. CONCLUSIONS

A novel frequency reconfigurable patch antenna with integrated MEMS actuators is presented for the first time. This patch can be dynamically reconfigured to operate at frequencies separated by about 1.6 percent of the nominal operating frequency. In addition, a novel on-wafer antenna pattern measurement technique is demonstrated.

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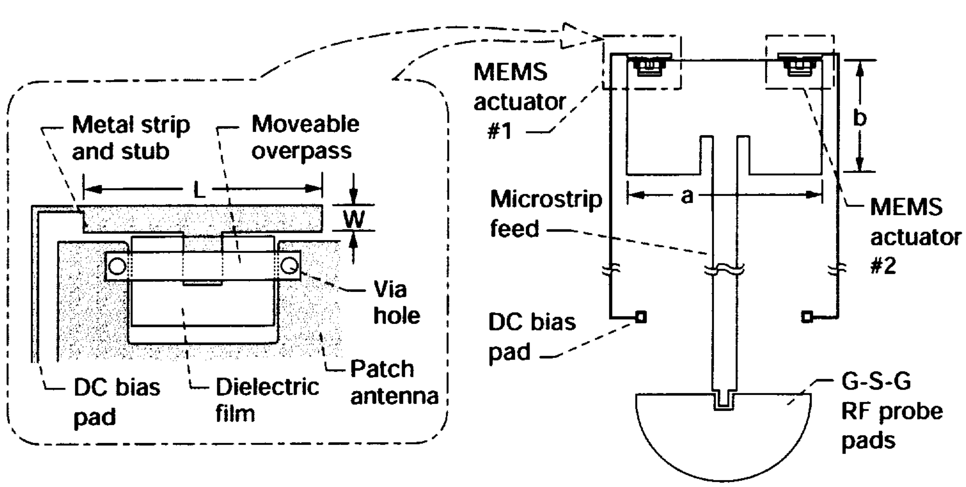

Figure 1.-Frequency reconfigurable patch antenna element with two independent MEMS actuators, L = 580 μm, W = 50 μm, a = 2600 μm, b = 1500 μm.

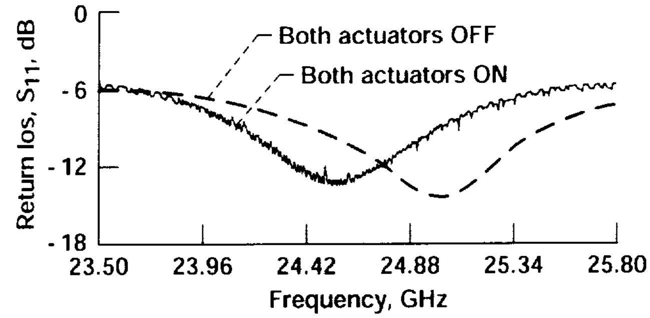

Figure 2.- Measured return loss demonstrating frequency reconfigurability with integrated MEMS actuators while maintaining good impedance match.

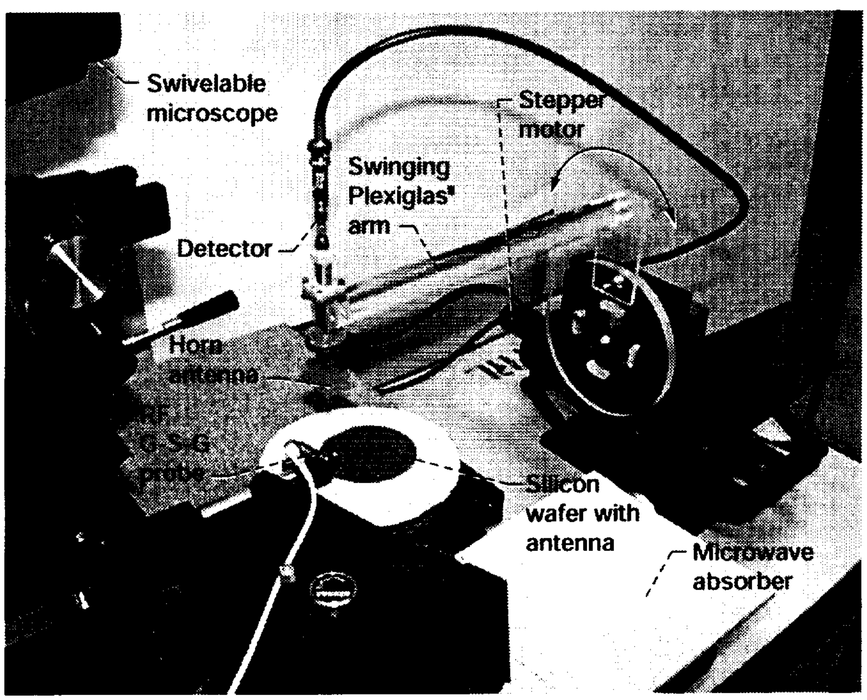

Figure 3.- Computer controlled on-wafer radiation pattern measurement set-up for MEMS actuator based patch antennas (surrounding microwave absorber panels have been removed).

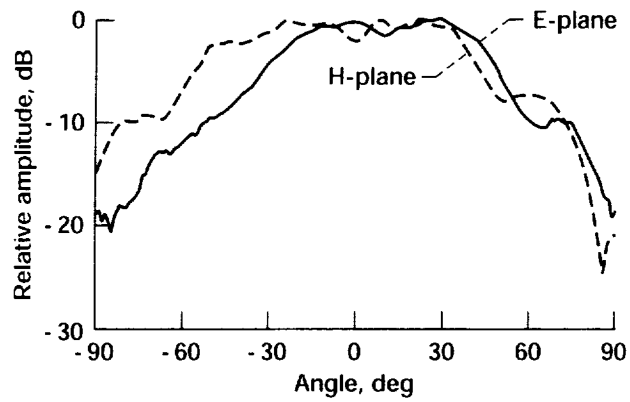

Figure 4.- Measured E and H-plane radiation patterns of the patch antenna.

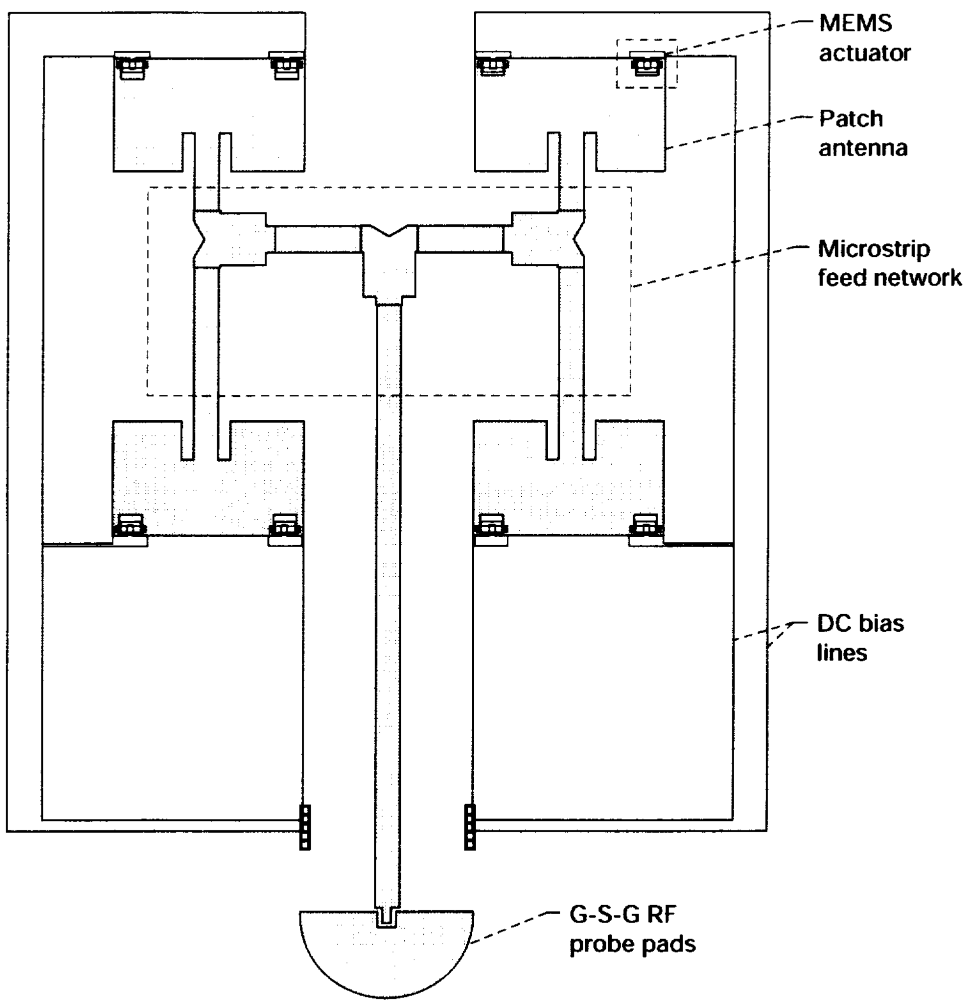

Figure 5.- Schematic showing a 2x2 patch antenna array with MEMS actuators and DC bias line for control.

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13. ABSTRACT *(Maximum 200 words)*

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