A Reflectarray Cell Based on a Tunable MEMS Capacitor

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Electronically tunable reflectarray cells based on varactor diodes have been demonstrated successfully in reconfigurable reflectarrays. One recent implementation (S. V. Hum *et al.*, *IEEE Microwave Wireless Compon. Lett.*, vol. 16, **6**, 422–424, 2005) offers substantial tuning range using a unique integration of the patch antenna with the varactor diodes. However, reflectarrays based on semiconductor tuning diodes suffer from reduced reflection efficiency due to significant diode losses, nonlinear effects caused by RF modulation of the varactor capacitance (particularly in transmission scenarios), and difficulties in operating at high frequencies due to substantial diode package parasitics. Tuning capacitors based on micro-electro-mechanical systems (MEMS) can address many of these issues. A MEMS capacitor possesses very little loss, is immune to RF modulation, and can be easily integrated monolithically with the antenna. The design of such a cell is the focus of this investigation.

A reflectarray cell based on the MEMS capacitor presented in (G. McFeetors and M. Okoniewski, *IEEE Microwave Wireless Compon. Lett.*, vol. 16, **1**, 34–36) has been designed and is shown in Figure 1. Two MEMS capacitors serially connect the patch-halves at the patch edge. An off-chip biasing structure (not shown) decouples the DC tuning voltage from the RF currents on the patch. For comparison purposes to previous varactor-based cells, the cell was designed for operation at 5.5 GHz. The design dimensions were $L = 17$ mm, $W = 14$ mm, and $g = 0.5$ mm. The patch and integrated capacitors are fabricated on a 1500 μm fused silica substrate ($\varepsilon_r = 3.8$).

The capacitor was designed to have a quiescent capacitance of 0.2 pF and to have a tuning ratio of 4:1. This is adequate to cover most of the tuning range achievable from the structure. The upper plot of Figure 2 shows the measured capacitance of a fabricated MEMS capacitor slightly larger than the one used in the design. The lower plot shows the simulated scattering characteristics of the cell based on an equivalent circuit model de-embedded from scattering measurements of a varactor-based cell, and MEMS capacitor measurements. Reduced loss in the MEMS device is clearly evident. Measurements of the fully integrated cell will be presented at the conference.

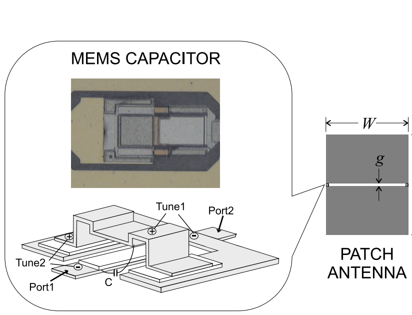

Figure 1: Cell layout

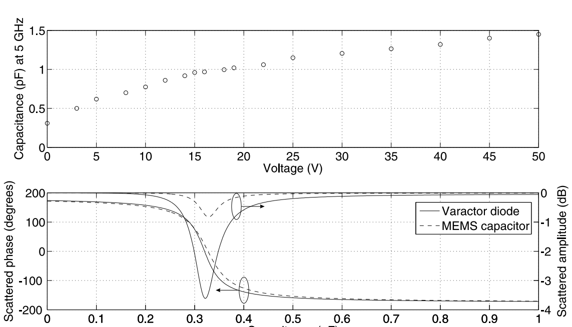

Figure 2: Reflectarray cell characteristics