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DYNAMIC TUNING OF ELECTROMAGNETIC BANDGAP

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Introduction: Recently periodic structures have captured an increasing interest among microwave designers. The periodicity has been exploited by researchers to achieve interesting propagation and radiation characteristics. One of the most interesting features is the presence of electromagnetic bandgap (EBG), i.e. frequency bands where the propagation of microwaves is forbidden in all or selected directions [1]-[2]. This unique property has contributed to enhance the performance of microwave components such as filters and sensors [3].

In this paper, one method for dynamically changing the position and of the width of the electromagnetic band gap of a periodic microwave structure is investigated. The one-dimensional structure considered here consists of twenty four unit cells. It has two dielectric layers: a relatively thick Alumina bottom layer and a thin Polyimide top layer, with a thickness ratio of 25:2. There is a microstrip on the top surface. Metal patches, sandwiched between the two layers, are selectively short circuited to the ground plane on the bottom surface, using vias and FET switches, to change the bandgap and hence the cut-off characteristics of the microwave structure (Fig. 1). The results obtained for different switching patterns indicate that this structure can be used in filtering and sensing applications in the S band (in 2.9 - 3.1GHz frequency range)

The Structure: The periodic structure, shown in Fig. 1, has two dielectric layers. The lower, grounded dielectric layer (layer 1) is Alumina (ε_r = 9.4). It is covered by an upper layer (layer 2) of Polyimide (ε_r = 3.5). The metal patches are sandwiched between these two layers. The analyzed model has 24 uniformly distributed and individually switchable patches. The dimensions of the patches are 450 mils and 30 mils in length and width, respectively. They are separated by a 40 mils gap. On the top of the Polyimide superstrate a microstrip line is placed. Its leading dimensions are as follows: 1800 mils in length and 10 mils in width. Two circular vias are drilled through the Alumina substrate from each patch to the ground. Patches are connected to vias through packaged field effect transistor (FET) switches, allowing one to selectively ground or float each patch by biasing the two FETs of the two ends. The microstrip line, vias and patches are realized in gold with a thickness of 0.5 mils. A previously published MMIC tunable structure [4] was aimed at monolithic fabrication in GaAs and other similar wafers for millimeter-wave applications. Its micrometer dimensions limit its fabrication to monolithic technologies and also restrict its bandgap to frequencies above 60 GHz. In this paper a scaled version of the structure is considered to facilitate fabrication using hybrid technologies and to obtain bandgaps below 6 GHz.

Numerical Results: The numerical analysis of the periodic structure consisting of 24 patches has been carried out using a commercially available transient solver [5]. The analysis of the scattering parameters is used to determine the bandgap of the structure. In particular the transmission coefficient S_{21} between the input and output ports of the structure is considered. Patches can be grounded or ungrounded selectively and dynamically by FET switches and the states of the 24 patches taken together determine the response of the overall structure.

The following convention has been adopted to indicate the state of each patch: when a patch is grounded (by biasing the 2 connected FET switches) the state of the patch is indicated by "1"; when it's in the floating state it is indicated by "0". In the studied periodic structure with 24 patches, each patch can either be in grounded or floating state based on the biasing of the FET switches. This mechanism allows one to introduce different periodic disturbances along the structure, each of them exhibiting bandgaps centered at different frequencies and of different width.

In Fig. 2, the transmission coefficients the following switching combinations are compared: 10, 1100, 111000. Each of them is repeated over 24 patches. As expected, different switching patterns exhibit different electromagnetic band-gap characteristics. Switching between these different patterns is possible by changing the biasing of the FETs, allowing dynamic control of the bandgap of the device. Note that the first cutoff frequency (at -10dB) of the structure can also be tuned by changing the switching pattern.

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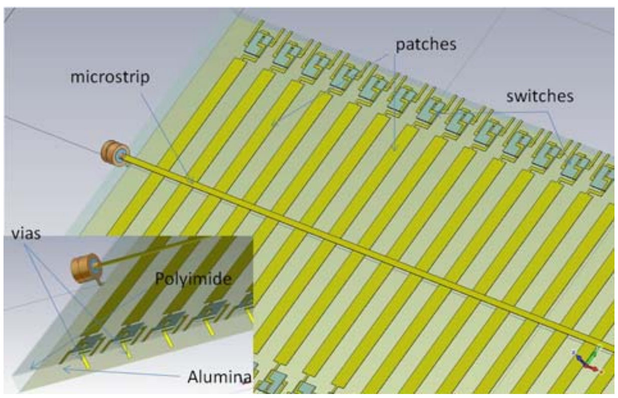

Fig.1: CAD model of the structure and of the excitation port.

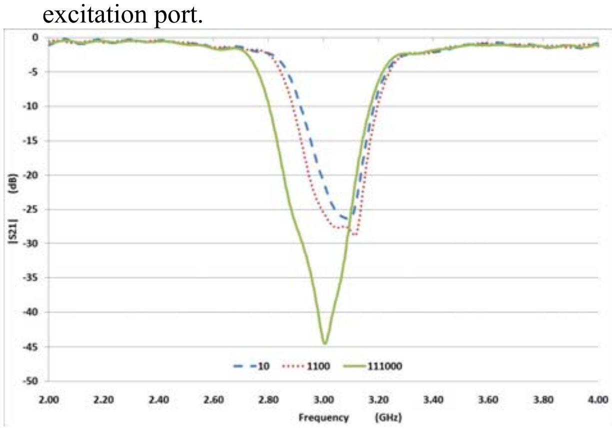

Fig.2: |S21| for "10", "1100", "111000" switching patterns repeated over twenty four patches