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Microwave Antenna with a Micromechanical Scanning

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1. Introduction

For automotive application, as radar assisted driving, the emission frequency is planned to be in the millimeter range[1]. For those frequencies, both beam forming and spatial scanning become expensive, involving complex electronic techniques. However, as the size of the microstrip antenna becomes compatible with microtechnology, a real interest exists in replacing the electronic scanning by a mechanical one, in order to reduce the equipment cost.This project is related to the realization and characterization of such microwave antenna, in which the spatial scanning is achieved by a rotational electrostatic actuation.

2. Device principle

The functional diagram of the device is depicted in figure 1. The upper plate, on which the microwave antenna is patterned, is suspended by two thin torsion hinges over two driving electrodes. The rotation is produced by electrostatic forces between the grounded antenna backside and electrode patterned on the silicon support. Fused quartz has been selected because of its good microwave properties and its ability to be processed. Around 60 GHz, a 1mm^2 antenna area is require for a 50μm thick fused quartz substrate. The geometrical dimensions and the shape of the torsion hinges was optimized with FEM (Finite Element Method) ANSYS simulations. Analytical electromechanical calculations clearly indicates that inclined electrodes allow to drastically reduce the actuation voltage, by a factor 3, compared to commonly used plane electrode configuration.

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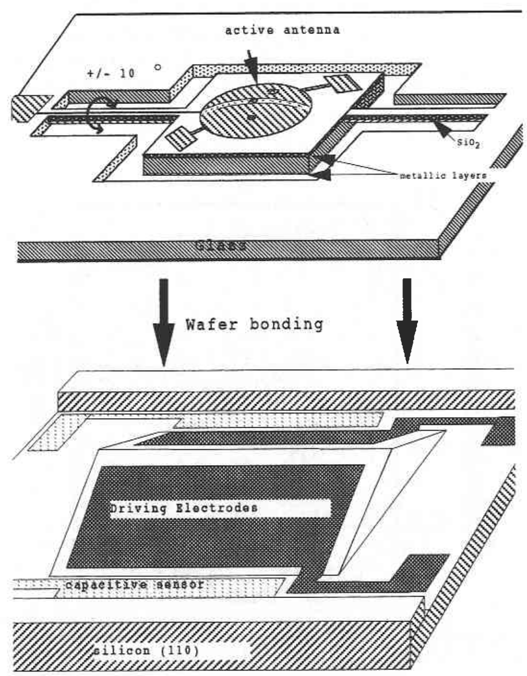

Fig.1 Functional diagram of a rotating antenna

3. Fabrication

The microwave antenna is a rectangular microstrip passive patch antenna, patterned on the 50μm fused quartz in a 1.5μm thick electroplated gold layer. A gold ground plate is used as mask for the time controlled wet etching of the substrate backside in BHF (Buffered HydroFluroridric acid). The 4μm thick hinges are etched from the upper side by RIE (Reactive Ion Etching) in CHF_3 gas. Figure 2 shows a SEM micrograph of the fabricated upper plate. By using a (110) oriented silicon wafer and an adequate anisotropic KOH (hydroxide potassium) etchant solution[2), inclined planes with 35.3° are obtained, as shown in Fig. 3. Gold electrodes are deposited by evaporation through a metallic mask on each side of this triangular silicon shape. SiO2 layers are used for electrical insulation between the silicon wafer and the electrodes as well as between the electrode and the upper plate. The two parts are finally clamped together.

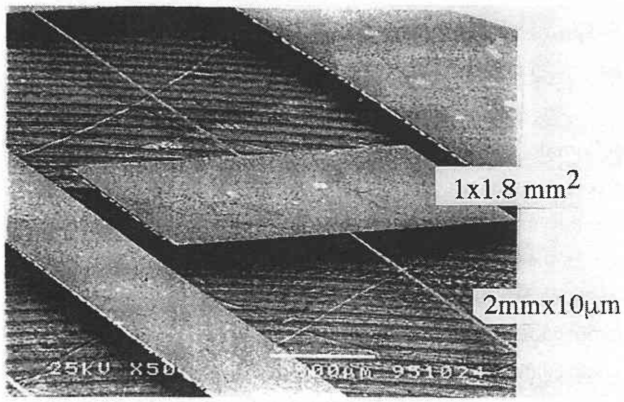

Fig.2 SEM picture of the upper part

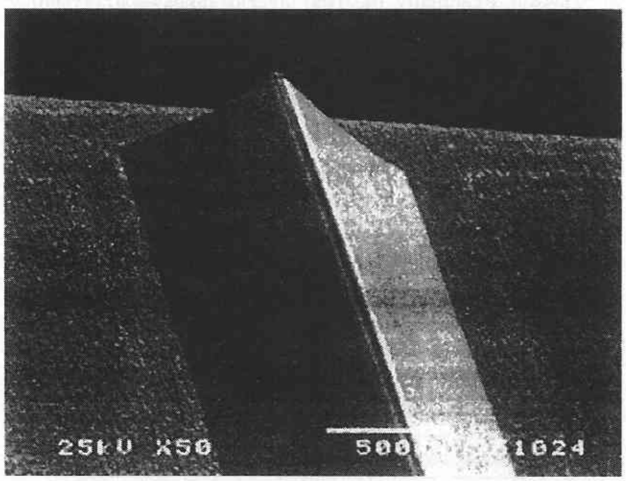

Fig.3 Triangular shape obtained by KOH etching

4. Characterization.

Microwave characterization[3)] have been performed at Institut d'Electronique et de Microelectronique du Nord (IEMN) under probes station on a HP network analyser. The antenna radiation mode is a TM01 mode with a radiation frequency of 61.6 GHz. This result is in good agreement with MDS (Microwave Device System) software simulations. A correct input matching is obtained. Controlled mechanical deflexion up to +/- 10° has been obtained by applying voltage lower than 80 V, between the upper plate and the electrodes underneath.

5. Conclusion

The feasibility of micromachined microwave antenna with its integrated mechanical scanning have been demonstrated in this project The micromachined antenna keeps good microwave properties and the mechanical rotation can be easily controlled for +/- 10° deletion. The required driving voltage has been reduced to 80 V, due to the special electrode configuration. This driving voltage can be easily produced by car battery. The rotating antenna has been transferred to IEMN for the final assembling with the MMIC oscillator. The system will be evaluated in real environment, as an radar assisted automobile driving system. This project is moreover an excellent illustration of the LIMMS project philosophy, an original microsystem is here realized by extending the MEMS technology toward new discipline, here toward microwave application.

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Reference

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2) S. Bouwstra, R. Legtenberg, H.A.C. Tilmans, M. Elwenspoek, Sensors and Actuators, A 21-23, pp332-335, 1990.
3) D. Chauvel, N. Haese, P.A. Rolland, D. Collard, H. Fujita, Proc. of MEMS 97, pp 84-88, 1997.