On the integration of a novel tunable silver deposit into MEMS surface micromachined resonators

Stefan Enderling 1, Charles Brown 2, Michael N. Kozicki 2, John Hedley 3 and Anthony J. Walton 1

1Scottish Microelectronics Centre, IMNS, School of Engineering and Electronics, University of Edinburgh, Edinburgh EH9 3JF, UK
2Ira A. Fulton School of Engineering, Arizona State University, Tempe, AZ 85287-5706, USA
3School of Mechanical and Systems Engineering, University of Newcastle, Newcastle upon Tyne NE1 7RU, UK

This paper presents an integration process of a novel tunable silver (Ag) deposit into MEMS surface micromachined bridge resonators. The mechanism of silver deposition is shown in Fig. 1. In this case, a blanket deposited Ag-doped chalcogenide glass film (Ge30 − Se70) serves as a solid electrolyte providing a medium for silver movement. Ag-ion migration in the electrolyte is induced by a DC voltage between an oxidizable Ag-anode and an inert cathode. This technology is potentially beneficial to the area of RF MEMS frequency tuning, because it can electrically control an Ag mass flow in real time along surface micromachined resonators. The successful integration of this novel mechanism was demonstrated by the movement of Ag ions across fixed-fixed suspended polysilicon microbeams which were covered with the described electrolyte. The Ag growth movement along the micro-resonators was detected using surface profiler, SEM and frequency measurements.

MEMS processes often combine micromechanics with electronics. These processes have greatly benefited from the integration of new active materials such as PZT [1] or ZnO [2]. However, new MEMS materials such as Ag-electrolytes cause contamination of silicon processing lines. Therefore, processes have to be developed to eliminate the above compatibility issue of novel materials to make them available to the MEMS field. In this paper, we present the successful integration of a new electrochemically Ag-deposition mechanism [3] into standard surface micromachined fixed-fixed suspended polysilicon microbeams. We also demonstrate DC voltage induced migration of Ag ions across polysilicon microbeams which results into a change of resonant frequency.

In total, arrays of four 15μm wide, 1μm thick and 75μm-200μm long polysilicon bridges have been fabricated. Solid electrolyte, Ag anode and aluminium cathodes were produced after surface micromachining of the micro-resonators. Fig. 2 summarizes the process. The integration of the Ag solid-electrolyte was performed after surface micromachining of the microbeams because of possible Ag contamination of the silicon fabrication line at Edinburgh University. Therefore, the solid-electrolyte, the Ag anode and aluminium bond contacts were produced using a combination of evaporation and shadow mask techniques at Arizona State University, where Ag contamination was not an issue.

After the integration of the solid electrolyte, microbeams were gold wire bonded in a 28 pin DIP and placed into the vacuum chamber for surface profiler and vibration measurements. Preliminary results are promising. Application of 3V resulted in the transport of Ag ions across the bridge, this coverage can be seen in figure 3. The two shorter structures both showed tuning with a -10% and -8% change in resonant frequency (i.e. reduction). The 150 μm and 200 μm bridges showed tuning of -1.2% and 6.2%, this inconsistency is attributed to the misalignment of the mask resulting in partial coverage of the bridges initially (Fig. 4). The next stage of investigation is to produce a uniform coverage of silver across the structures and its subsequent removal with a reverse biased field. In conclusion, a fully functional novel electrochemical silver deposition technique was successfully integrated into compliant surface micromachined polysilicon beams. This Ag deposition technology can provide a mechanism for real time frequency tuning in RF MEMS especially for time keeping applications.

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Submiting author: Stefan Enderling. Scottish Microelectronics Centre, IMNS - Institute for Integrated Micro and Nano Systems, University of Edinburgh, King’s Buildings, West Mains Road, Edinburgh EH9 3JF, UK; Telephone: +44 (0) 131 650 5610, Fax: +44 (0) 131 650 7475, Email: stefan.enderling@ee.ed.ac.uk

REFERENCES

3. Fabrication and Packaging Technologies

**ABSTRACT**

**IDENTIFICATION NUMBER:** 0189

**Polysilicon**

Silicon dioxide

Silicon

Growing Ag electrode

Electrolyte

Ag doped cathode

Aluminium bond contact

Polysilicon

Fig. 1. Schematic of a polysilicon microbeam with integrated electrolyte, Ag anode and Aluminium contacts.

(a) LPCVD polysilicon (1µm) @ 585°C

(b) Chalcogenide glass (80 nm) + Ag (15 nm) deposition

(c) Photodissolution of Ag (20 min.)

(d) Silver deposition (50nm) and shadow mask

(e) Aluminium deposition (400nm) and shadow mask

Fig. 2. Integration process sequence for tunable silver deposit.

Anode

Cathode

No silver deposition

Bias voltage 0V

Silver deposition

Bias voltage 3V

Fig. 3. Intensity scan of a 150µm long, 15µm wide and 1µm wide polysilicon beam before and after silver deposition.

150µm

200µm

Misalignment of Ag and Aluminium at the Ag–anode

DC voltage induced silver deposition

Fig. 4. Partial coverage of microbridges with Aluminium and Ag due to misalignment. Measured frequency changes are -1% for 150µm and +6% for 200µm long polysilicon beam.