

DOME-SHAPED-DIAPHRAGM RESONATORS WITH WINE-GLASS MODE VIBRATION

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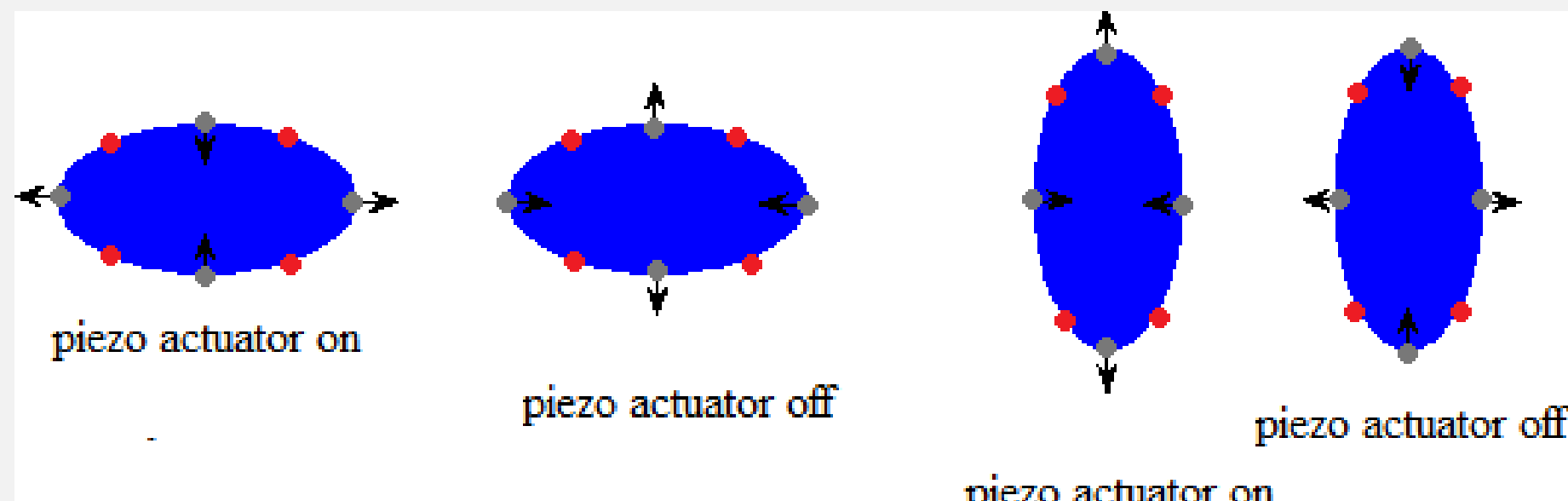
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Motivation

- Measurement of angle and orientation has always been very important in different application from smartphones to missiles and space-ships.
- Gyroscopes are sensors for these measurements.
 - Hemispherical Resonator Gyroscope has been the choice for high value space missions due to their high performance small size and no wear out.
 - We are trying to design a micro version of these already largely used devices.
 - First step to do so is to design a dome-shaped-diaphragm resonator with wineglass mode vibration.

Design

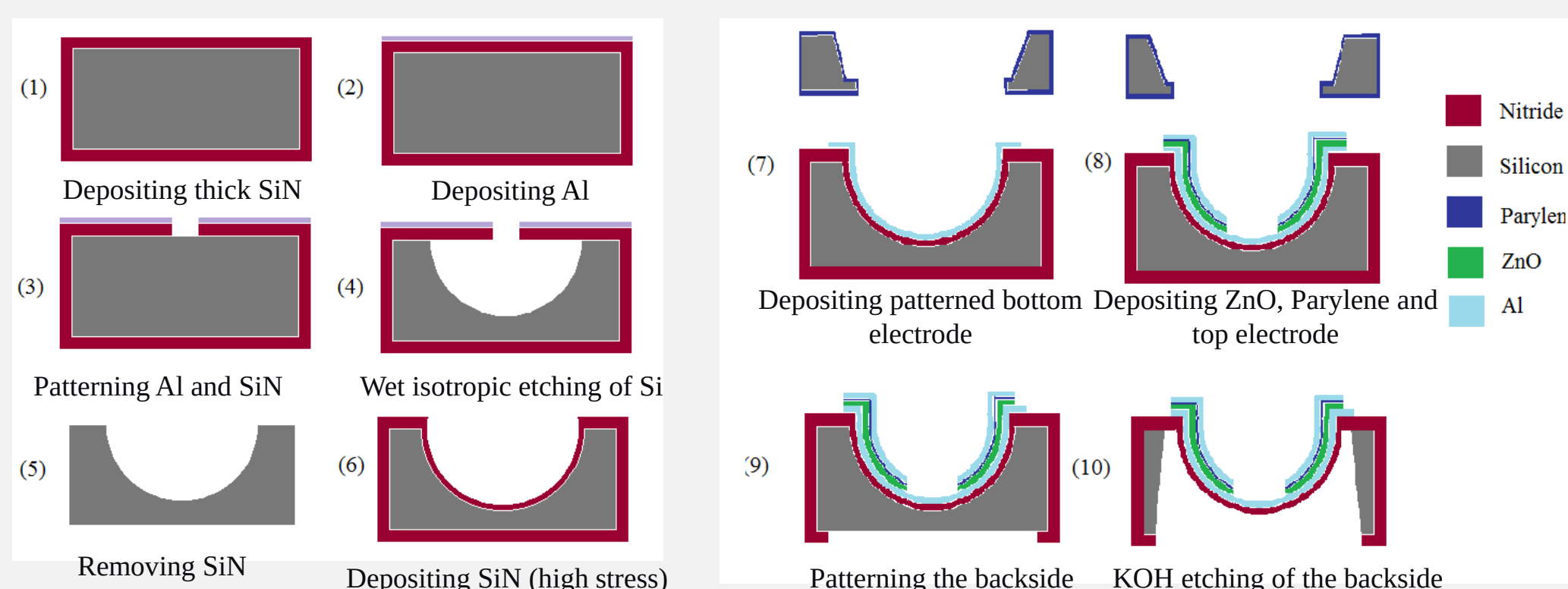
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How a 4-node wineglass mode is produced by the four piezoelectric transducers mounted on the anti-nodal lines of the dome diaphragm

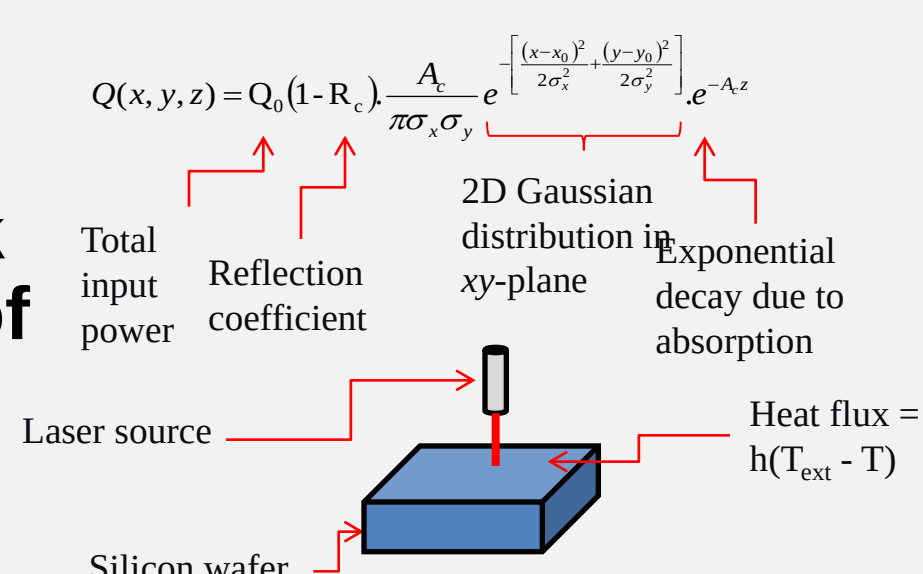
Fabrication

- A batch process with silicon wafer, based on isotropic etching of silicon

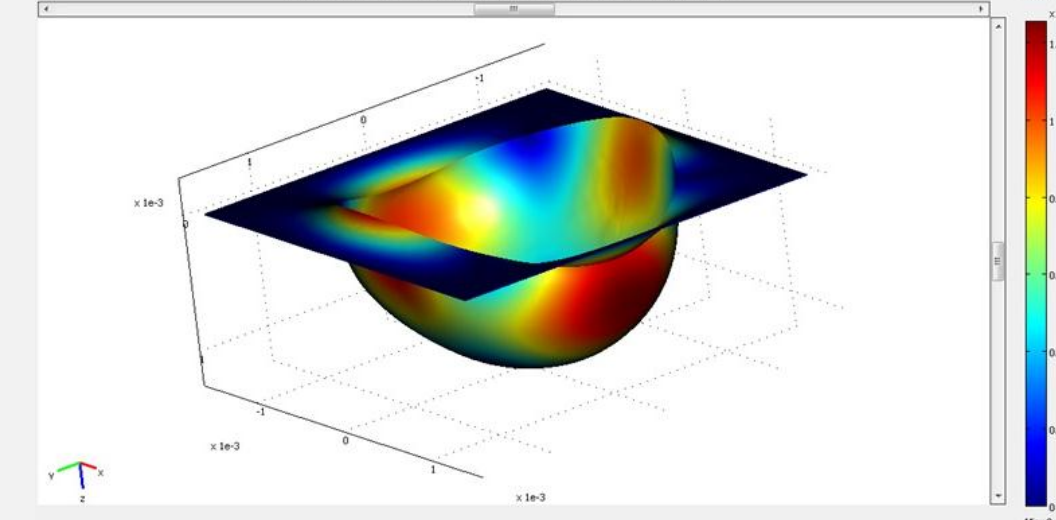


Fabrication Process alternative

- In order to achieve larger dome and considering our limitation due to etch mask we came up with the idea of damaging silicon before etching using a laser

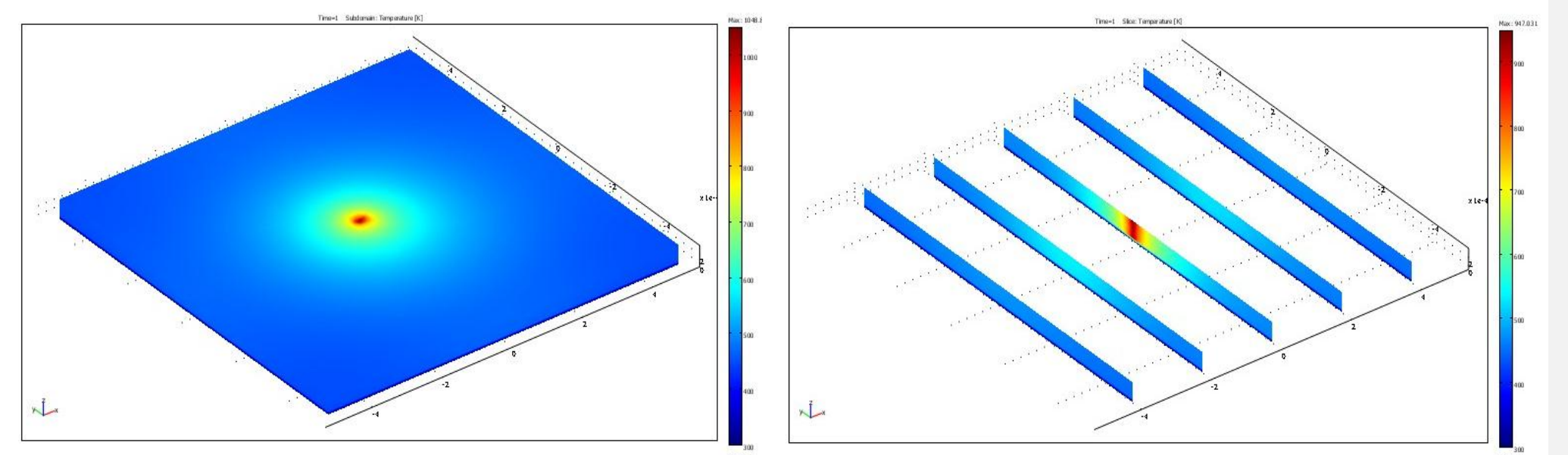


Simulation Results



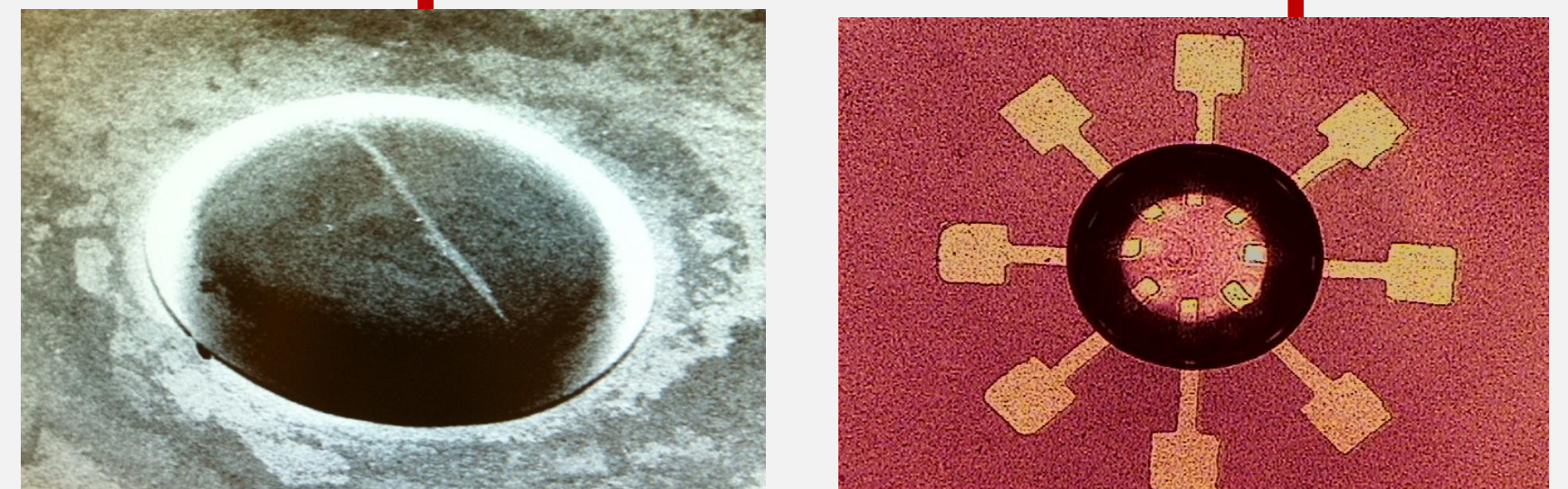
FEM simulation results of the device

- Finite Element Method simulation results of our device:
 - 4 node wineglass mode has been observed in the designed frequency.



FEM simulation results of the laser heating of silicon wafer, penetration of laser heat can be seen in the right side figure

Fabricated Device and Experimental Setup



SEM image of backside of the device and a picture of top side of the transducer showing the electrodes



Board and electrical connections for actuation and sensing

Experimental Results

- We have 4 actuators and 4 sensors, actuators also can be used as sensors.
 - In order to show 4-node wineglass mode resonance we actuate two actuators on every other side of the device (1 and 5 in the left picture) and monitor sensors.
 - If we have 4-node wineglass mode resonance we expect to see a signal at the middle sensor (3 in the picture) which is 180° out of phase from actuation signal.
 - We approved these results by measurement (left side picture)

