Frequency Analysis of Si-Wafers with Variable Size and Boundary Conditions

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Abstract

INTRODUCTION:
Silicon wafers represent key elements in modern microelectronics or photovoltaics. Technological fabrications of wafer sizes with large diameters (e.g. 450 mm) allow an efficient realization for integrated circuits at low cost. However, this material shows a high sensitivity to vibrations that strongly depends on size and the positioning as well as orientation of a wafer in a mounting, realized e.g. by single fixed points located at the rim of the device.

Numerical simulations of deformation and vibrations response are thus of high importance for the optimization of handling of wafers during mounting and storage.

USE OF COMSOL MULTIPHYSICS®:
We use COMSOL Multiphysics to set up the wafer geometry (Figure 1). Starting for the structural mechanics module we chose the solid state mechanics and chose silicon as basis material. The elastic parameters are simulated via the elasticity matrix provided by COMSOL. We apply a three-dimensional model with the diameter and the hight of the geometrical cylinder as global parameters. For simulations with 4 fixed boundary points we additionally introduce an angle characterizing the separation of neighboring fixing points at the rim.

RESULTS:
We performed simulations of Silicon wafers of circular symmetry with diameters in the regime 150 mm.. 450 mm. For these geometries we systematically varied the number and positioning of fixing point at the rim as realized in typical experimental situations (Figure 2). It could be shown, that the vibration frequencies shift with changes in the mounting. Furthermore the mode shapes can be controlled by suitable positioning and orientation of the wafer in the holding environment in agreement to typical experimental observations. In particular, a deliberately selected asymmetry may stabilize the system by suppressing vibrations.

CONCLUSION:
The control or even suppression of oscillations in Silicon wafers of large diameters is of large importance for the optimization of the mounting and handling of wafers during processing, transport and storage. The results of this work may thus be of importance for future developments in Silicon material technology.

Figures used in the abstract

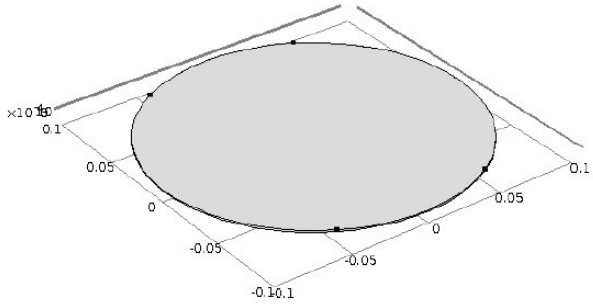

Figure 1: circular wafer geometry with variable boundary conditions

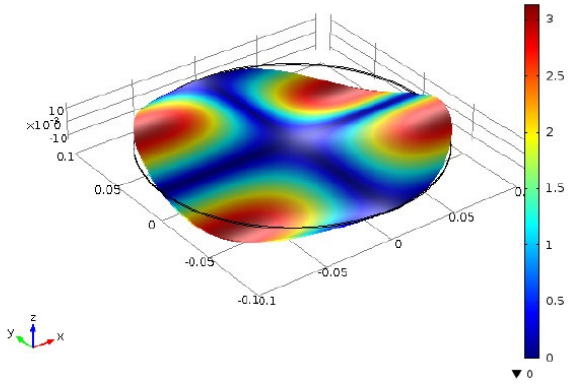

Figure 2: frequency analysis of