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Heterodyne laser-doppler interferometric characterization of contour-mode resonators above 1 GHz

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Background, Motivation and Objective

AFM has been used to image and characterize vibrations of MEMS resonators [1]. Characterization of MEMS resonators using heterodyne interferometer is of interest because it provides accurate measurement of resonances and broadband vibrations [2,3] without contacting the surface of the resonators.

Statement of Contribution/Methods

We report a special technique to measure frequencies and vibrations of contour-mode resonators (Fig. 1a) up to 1.2 GHz using only a 618 MHz carrier frequency (fc). The detector signal of the vibrometer is digitized by a fast oscilloscope and demodulated off-line in a computer (Fig. 1b). This method enabled us to realize an algorithm to extend the measurement bandwidth by a factor of 2. The algorithm takes only the frequency components of the detector signal into account which are higher than fc to construct an IQ-(in-phase, quadrature) signal from a virtual carrier signal with 2x the original frequency. The Rohde & Schwarz SMBV100A broadband Vector Signal Generator has been used to excite the specimen with a periodic chirp signal [4]. We set the spacing of the periodic-chirp frequencies to the resolution bandwidth of the measurement and adjusted the evaluated frequencies to the center of the FFT lines of the demodulated spectrum to determine the vibration amplitudes without leakage. In addition, the energy is distributed equally to all frequency components.

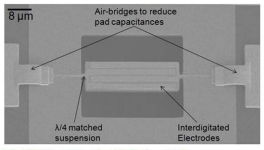
Results

A PZT transduced high-overtone width-extensional mode resonator was first characterized electrically on an RF probe station. Frequency response in air at room temperature is recorded in Fig. 1c. Optical measurement using a heterodyne interferometer technique was performed. Resonator's displacement as a function of frequency was plotted in Fig. 1d.

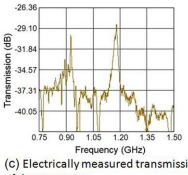
Discussion and Conclusions

A novel characterization technique of MEMS resonators above 1 GHz using heterodyne interferometer was performed. By measuring modes of vibrations optically, misalignment in lithography that leads to parasitic modes and unexpected resonance peaks can be identified without contacting the surface of the resonators.

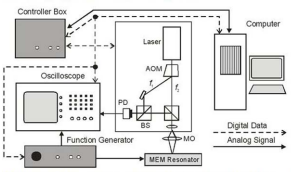
[1] San Paulo et al, Microelectronic Engineering, pp. 1354-1357 (2007).
[2] Rembe et al, SPIE 7098, pp. 70980A-70980A-12 (2008).
[3] Stoffels et al, to be published at Transducers '09.
[4] Schüssler et al, SPIE 4072, pp. 354-360 (2000).



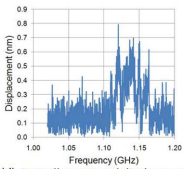
(a) SEM image of a high-overtone width-extensional mode resonator



(c) Electrically measured transmission of the resonator



(b) Heterodyne laser Doppler measurement setup



(d) Optically measured displacement of the resonator