**AC Electrothermal Characterization of Doped-Si Heated Microcantilevers Using Frequency-Domain Finite Element Analysis**

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**Introduction:** Atomic force microscopy (AFM) is used for data writing and reading, localized thermal analysis, and surface scanning in nanometer scale. In AFM, deflection of the cantilever changes reflected laser intensity measured by photo-detector. A Heated cantilever is made of high phosphorous doped legs and a lightly doped heater zone near the tip (Fig. 2). An experimental and numerical AC characterization of the heated cantilever using the 3ω method, done in this study, provides deep understanding of frequency-dependent electrothermal behaviors of the heated cantilever.

**Computational Methods:** The AC electothermal behaviors of the heated cantilever suspended in the environment box has been computed in the frequency domain using the governing equations:

\[
\frac{\partial T(r,t)}{\partial t} = k \nabla^2 T(r,t) + \frac{Q(r,t)}{V}\]

**Fourier Transform**

\[
\tilde{Q}(\omega) = k \nabla^2 \tilde{T}(\omega) + \frac{\tilde{Q}_{in}(\omega)}{V}
\]

**Complex Decomposition**

\[
\tilde{Q}(\omega) = k \nabla^2 \tilde{T}(\omega) + \frac{\tilde{Q}_{in}(\omega)}{V}
\]

**In-Phase**

\[
\tilde{Q}_{in}(\omega) = k \nabla^2 \tilde{T}_{in}(\omega)
\]

**Out-Phase**

\[
\tilde{Q}_{in}(\omega) = k \nabla^2 \tilde{T}_{in}(\omega)
\]

**Results:** 3ω voltage signals of the cantilever in vacuum is calculated by the frequency-domain COMSOL simulation. Largest error is 6.05%. Temperature distribution of the cantilever suspended in air is calculated for different frequencies. The heater size effect on the 3ω voltage signal is also studied.

**Conclusions:** A frequency-domain FEA model is developed using COMSOL Multiphysics to predict the frequency dependent of electrothermal behaviors of the heated cantilever. The developed method can be applied for the simulation of the frequency-dependent thermal behaviors for different MEMS devices.

**References:**

Excerpt from the Proceedings of the 2014 COMSOL Conference in Boston.