Prototype measurement system for frequency response analysis of microcantilever sensors

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Abstract

Microcantilever sensors operating in a dynamic mode are well known as one of the most sensitive detection for chemical and biomedical applications. Particles or bio-species adhered on the sensors will result in a shift of its resonant frequency. In this study, a measurement system for dynamic response analysis of microcantilever sensors was developed. The system was composed of: (1) the optical beam deflection measurement system, which was used to monitor the oscillation of the microcantilever sensors; (2) the sensor holder with a piezoelectric element for driving the microcantilever; (3) the optical focusing system; and (4) a lock-in amplifier that was employed to detect a small level of the microcantilever vibration. Various designs of microcantilever sensors were studied. Results and analysis were discussed in detail.

Methods & Theory

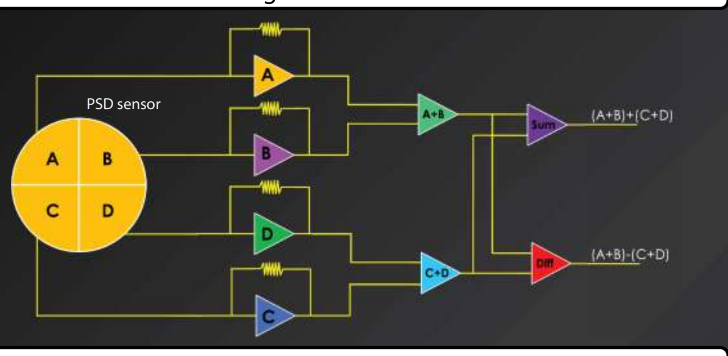
The basic mechanical parameters of a microcantilever are the spring constant and the resonance frequency. The spring constant k is proportionality factor between applied force. This relation is called Hooke's law. [F = -kz] The spring constant yields the stiffness of the cantilever. For a rectangular cantilever of length l, the spring constant can be written as e.q.(1) and the resonance frequency can be expressed as e.q.(2)

$$k = \frac{Ebh^3}{4l^3} \quad \text{......(1)}$$

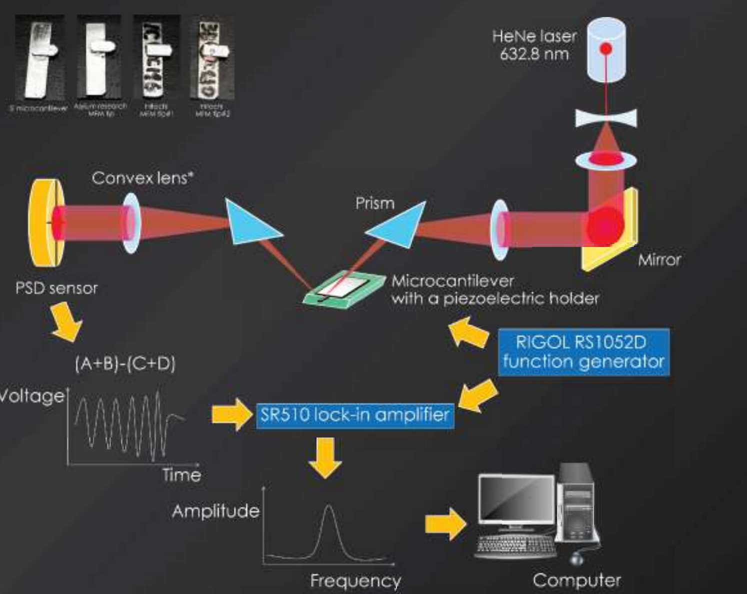
$$f_{res} = 0.32\sqrt{\frac{k}{m}} \quad \text{......(2)}$$

With b = cantilever's width
h = cantilever's heigh
l = cantilever's length
E = Young modulus

Schemetic diagram of PSD sensor interface



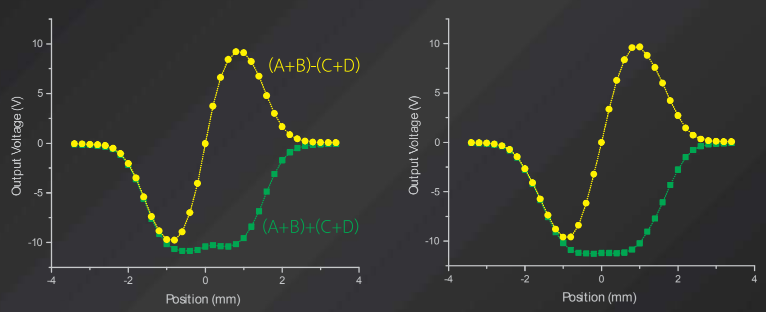
The prototype measurement system



Experimental results

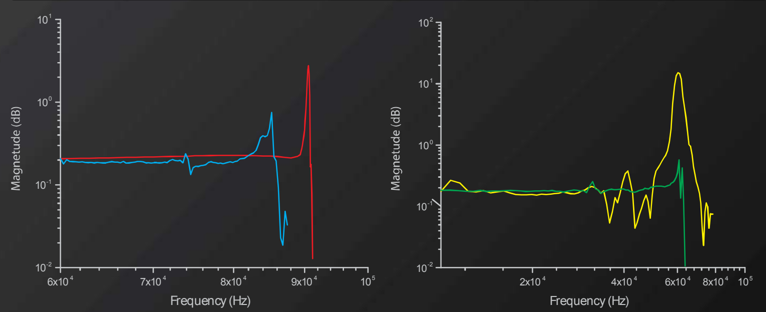
Response of PSD sensor when varying z-axis position

With convex lens | No convex lens



From the reults; when placed the convex lens in front of PSD sensor, the laser beam was too small to measure the incidence light. From the left graph; voltage output,[(A+B)+(C+D)], when the incidence laser position is Z=0 this voltage output isn't the highest value. So, in next experiment, we didn't place the convex lens in front of PSD sensor.

Frequency respose of microcantilevers



Form the results, microcantilevers response differently when supply 600mV voltage input and vary frequency form 10kHz to 100kHz. The parameter that can express the frequency response is Magnitude(dB) that is express in e.q.(3)

$$dB = 10\log\left(\frac{V_{pp\,[(A+B)-(C+D)]}}{V_{input}}\right) \quad \text{......(3)}$$

Conclusion

1. The measurement system doesn't place the convex lens in front of PSD sensor because incident the laser beam will contact to the middle of PSD sensor that doesn't detect light.
2. The developed system can measure the microcantilever resonance frequency range in 10kHz to 100 kHz. 4 microcantilevers(Si, Asylum, Hitachi#1 and #2) that had been measured have 90.kHz, 84.8kHz, 60.16kHz and 60.37kHz respectively.
3. In the future, We're going to use Matlab to control and mesure. Receptor coated microcantilever were use to detecting particle and bio-species.

References

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