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Ultrasensitive mass sensing using a single cantilever coupled with a computational cantilever

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Abstract: Mass sensing based on the eigenmode shift of coupled cantilevers achieves very high sensitivity. In this method, identical cantilevers and the weaker coupling stiffness between them enable higher sensitivity. However, the sensitivity is restricted because the identity of cantilevers and the coupling stiffness depend on machining accuracy. To maximize the sensitivity, we propose completely identical weakly coupled cantilevers using a single cantilever and a digital computer. The digital computer calculates the dynamics of one of the conventional coupled cantilevers and the effect of coupling. Then, the calculated effect of coupling moves the single cantilever's supporting point. The system enables us to set the physical parameters of the cantilever whose dynamics is calculated and the coupling stiffness appropriately. In addition, to use even in viscosity environments, we apply the self-excited oscillation with a steady-state amplitude proposed in our previous work to the coupled cantilevers. We realized the identical coupled cantilevers and their arbitrary coupling stiffness in the experiment using the prototype system with a macrocantilever. Furthermore, we achieved ultrasensitive mass sensing.

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