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Nano-mechanical Resonantor Sensors for Virus Detection

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Micro and nanoscale cantilever beams can be used as highly sensitive mass detectors. Scaling down the area of the cantilever allows a decrease in minimum detectable mass limit while scaling down the thickness allows the resonant frequencies to be within measurable range. We have fabricated arrays of silicon cantilever beams as nanomechanical resonant sensors to detect the mass of individual virus particles. The dimensions of the fabricated cantilever beams were in the range of 4-5 μm in length, 1-2 μm in width and 20-30 nm in thickness. The virus particles we used in the study were vaccinia virus, which is a member of the Poxviridae family and forms the basis of the smallpox vaccine. The frequency spectra of the cantilever beams, due to thermal and ambient noise, were measured using a laser Doppler vibrometer under ambient conditions. The change in resonant frequency as a function of the virus particle mass binding on the cantilever beam surface forms the basis of the detection scheme. We have demonstrated the detection of a single vaccinia virus particle with an average mass of 9.5 fg. Specific capture of the antigens requires attachment of antibodies, which can be in the same range of thickness as these cantilever sensors, and can alter their mechanical properties. We have attached protein layers on both sides of 30nm thick cantilever beams and we show that the resonant frequencies can increase or decrease upon the attachment of protein layers to the cantilevers. In certain cases, the increase in spring constant out-weighs the increase in mass and the resonant frequencies can increase upon the attachment of the protein layers. These devices can be very useful as components of biosensors for the detection of air-borne virus particles.

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