High Q MEMS resonators with graphene electrodes : evaluation of the electrode-induced energy losses

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In applications such as vibrating inertial sensors and crystal oscillators, resonators with high quality factor Q are strongly sought after: higher Q leads to improved beam frequency stability – i.e. the bias stability of sensors - and better signal to noise ratio. Among the main dissipative mechanisms responsible for finite Q, viscous damping within the electrodes become of major importance as the size of resonator decreases. But routes to improve it have been little explored, especially on resonators with complex electrode design [2]. A Kelvin-Voigt model predicts that the quality factor related to viscous damping Q_{visc} is inversely proportional to the electrode thickness and its viscosity [3].

The present work focuses on evaluating the possibility to improve Q_{visc} by replacing the standard thick Cr/Au electrodes by monolayer graphene. This study has been carried out on a Vibrating Integrated Gyrometer, which consist of a high-Q quartz tuning fork with two close resonant frequencies (in-plane and out-of plane modes). The quality factor is successively measured on the same resonator (i) with gold electrodes, (ii) after wet etching of the electrodes and (iii) after a CVD graphene transfer on most of the surface of the resonator (Fig. 1b). Q is obtained through vibration amplitude spectrum measurements carried out under vacuum at room temperature using interference franges contrast method in an optical vibrometer (Fig. 1a).

As illustrated in Fig. 1c-d., replacing the gold electrode by graphene allows a reduction of the electrode related losses by a factor around 10 for the In-plane mode and around 3 for the out-plane mode. Further investigation is needed to understand the damping mechanism associated with graphene. Moreover, a method to pattern the graphene after its transfer on the resonator has to be developed and will be discussed in the poster.

References

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Figures

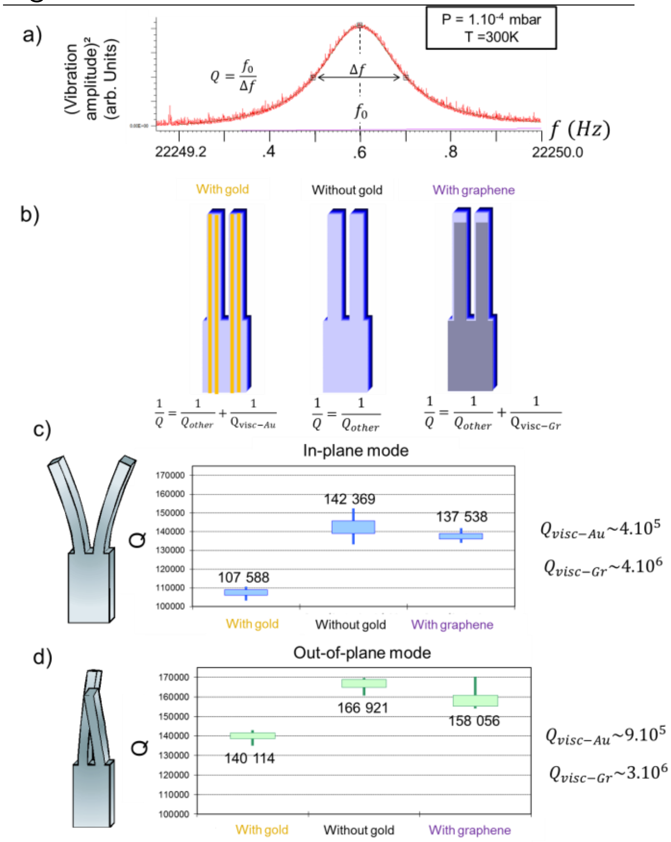

Figure 1: a) Typical vibration amplitude spectrum obtained by averaged optical interferometry fitted by a Lorentzian b) scheme of the three configurations of the tuning fork c) Quality factor measured on the in-plane mode (scheme of the mode on the left) d) Quality factor measured on the out-of-plane mode (scheme of the mode on the left)