PHOTOACOUSTIC spectroscopy utilizing AFM-based CANTILEVER detection

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The sensitivity in the photoacoustic spectroscopy is limited by the microphone. The replacement of a microphone with a cantilever one enhances remarkably the sensitivity of photoacoustic gas detection:

J. Kauppinen, K. Wilcken, I. Kauppinen, V. Koskinen, “High sensitivity in gas analysis with photoacoustic detection“, *Microchem. J.* **76** (2004)151-159.

V. Koskinen, J. Fonsen, J. Kauppinen, I. Kauppinen, "Extremely sensitive trace gas analysis with modern photoacoustic spectroscopy", *Vibr. Spectrosc.* **42** (2006) 239 - 242.

The combination of sensitive microphones and micromechanical elements with laser techniques - new approaches to photoacoustic detection and for chemical sensing possibilities.

graphene leafs:

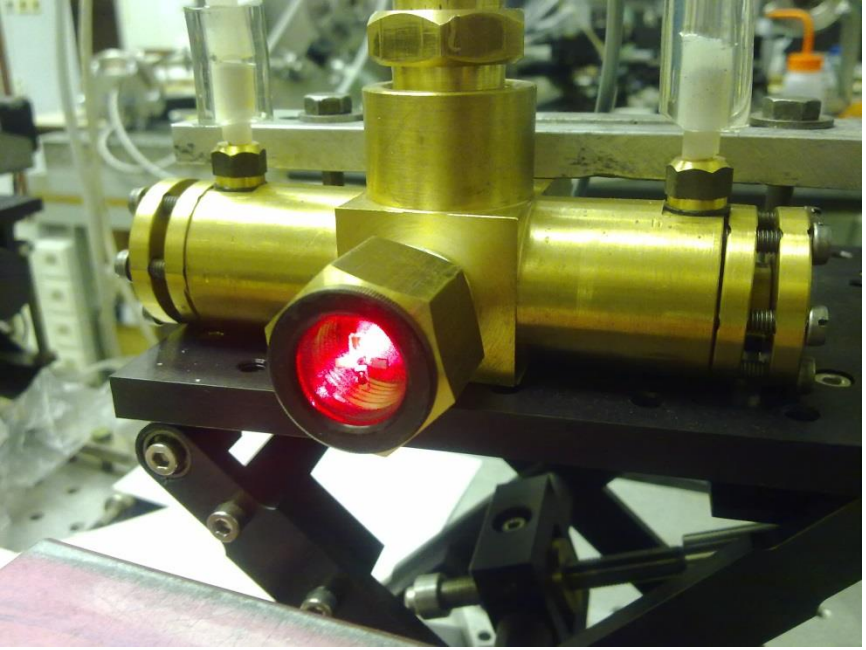
outstanding electromechanical properties and impressive sensitivity as a mass detector

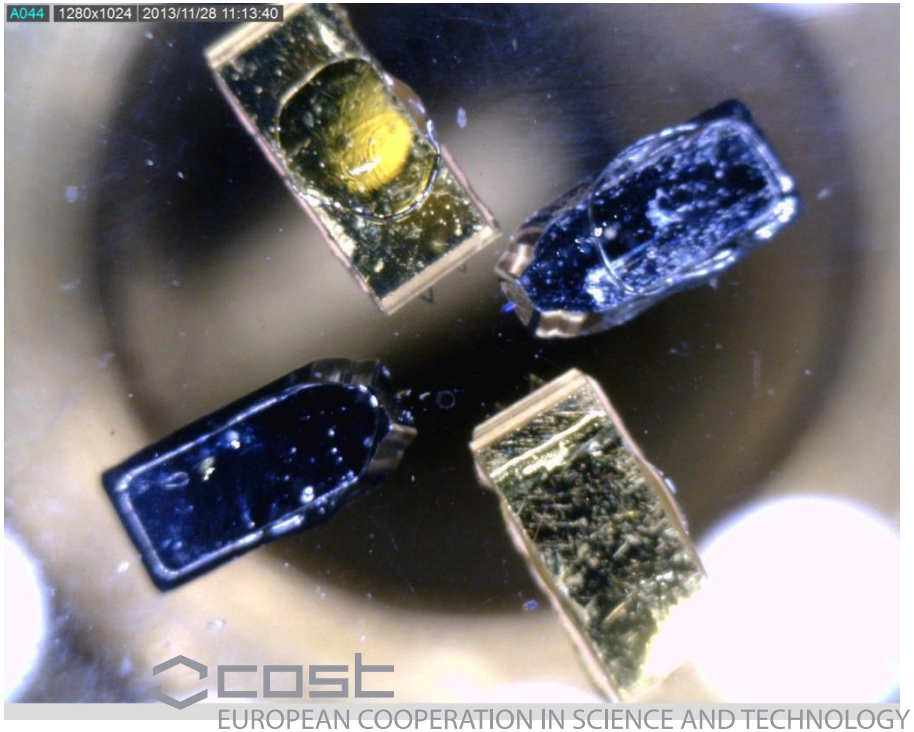
its utilization as nano/micro-lever sensing devices for chemical analysis:

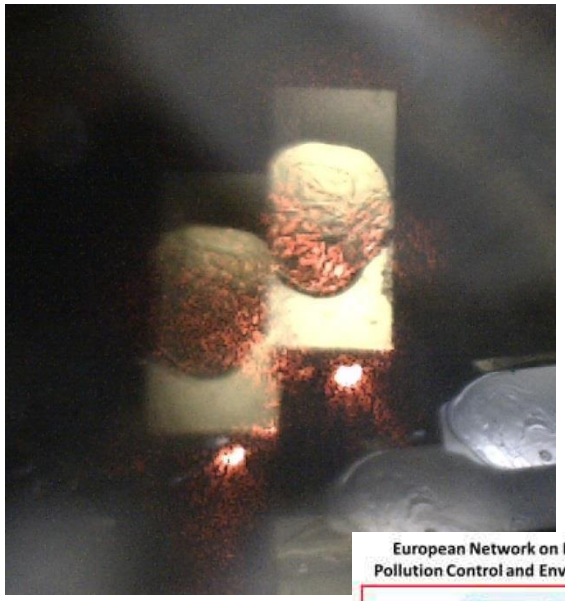
P. Li, Z. You, T. Cui, “Graphene cantilever beams for nano switches“, *Applied Physics Letters*, **101**, (2012) Issue 9, id. 093111.

We have tested:

- AFM-based silicon cantilevers in a square arrangement and
- graphene sheets in the form of a circular membrane.







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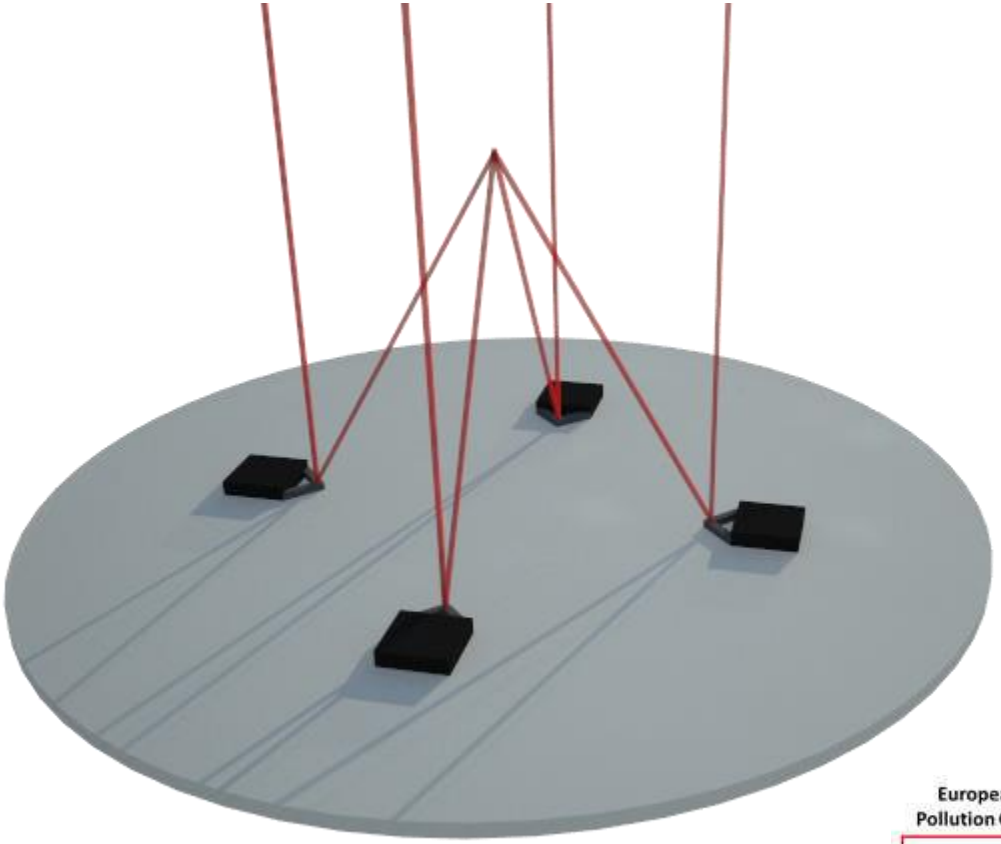
Scheme of detection part consisting silicon cantilevers:



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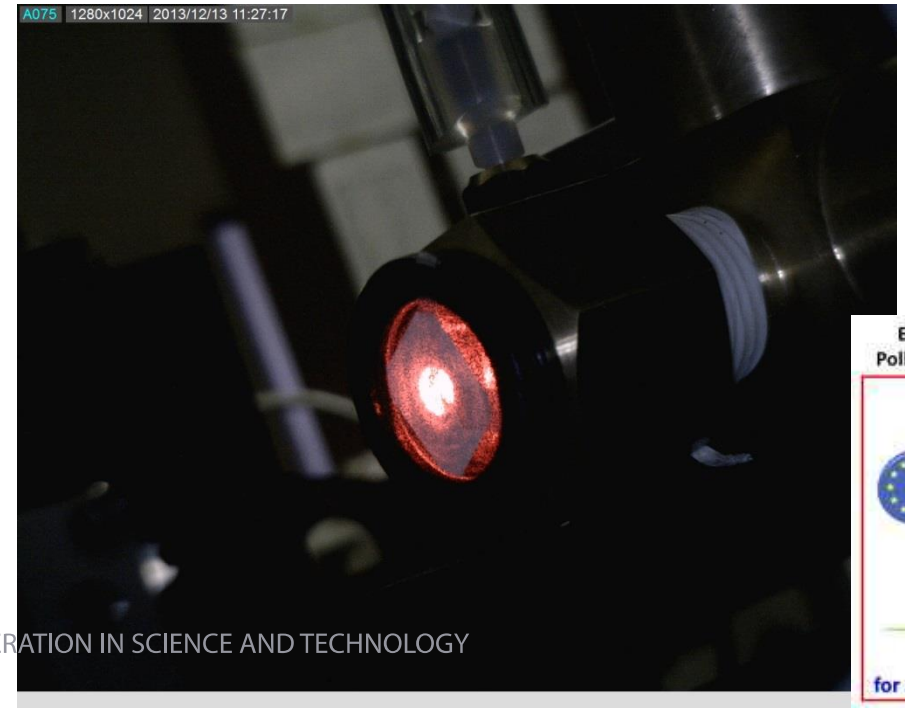
Membrane for photoacoustic detector has been prepared from multilayer graphene (MLG) by micromechanical cleavage which is an essential component of sheets stripped-off basal plane highly ordered pyrolytic graphite (HOPG, ZYH Grade, Bruker, USA) :

Novoselov, K. S.; Geim, A. K.; Morozov, S. V.; Jiang, D.; Zhang, Y.; Dubonos, S. V.; Grigorieva, I. V.; Firsov, A. A. (2004). "Electric Field Effect in Atomically Thin Carbon Films". Science 306 (5696): 666–669.

MLG leafs (thickness <10 μm) have been mounted on glass window of cuvette for photoacoustic spectroscopy and used for detection of acoustic waves by laser beam reflected to CCD detector.



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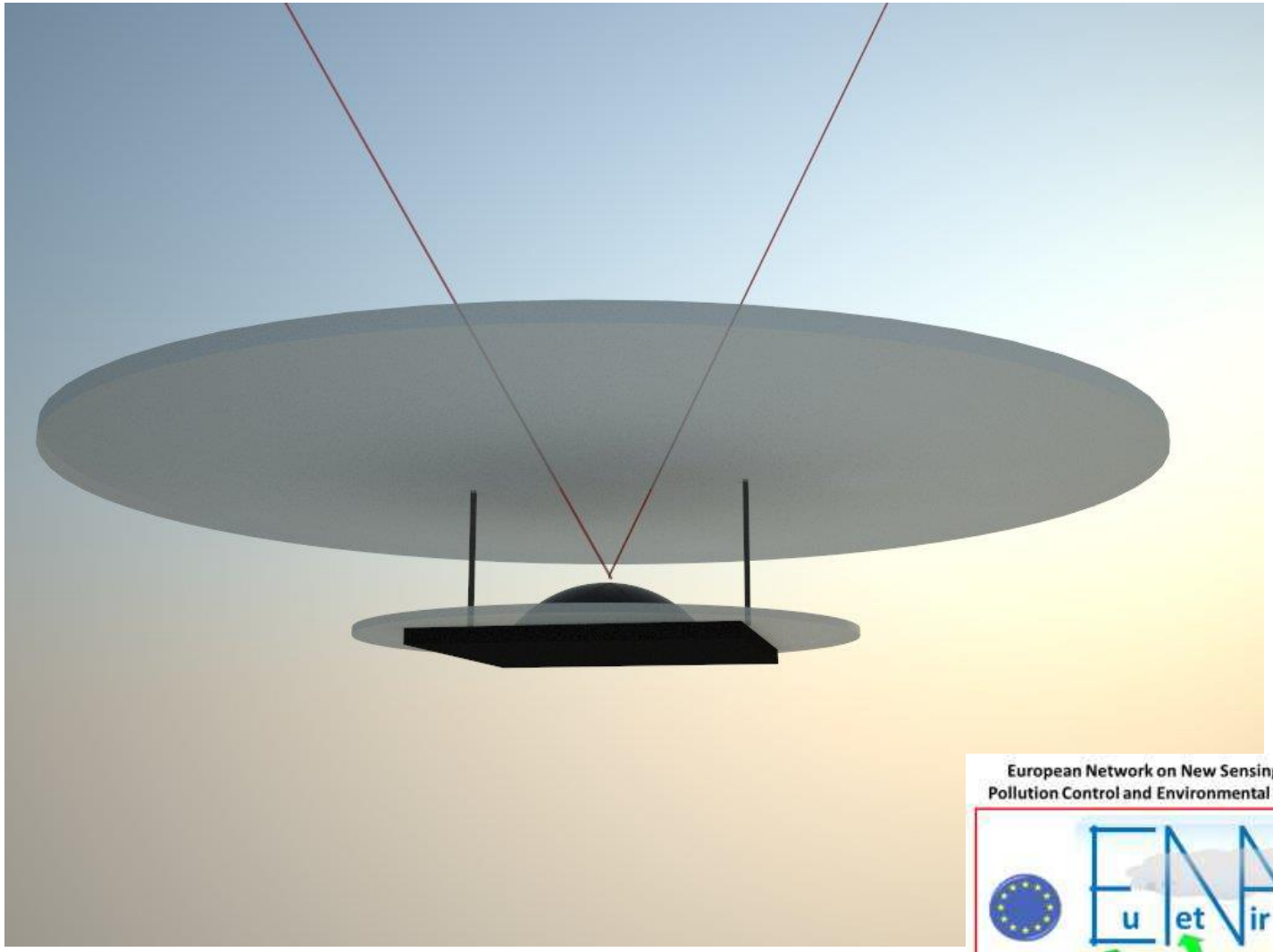
Scheme of detection part based on graphene:



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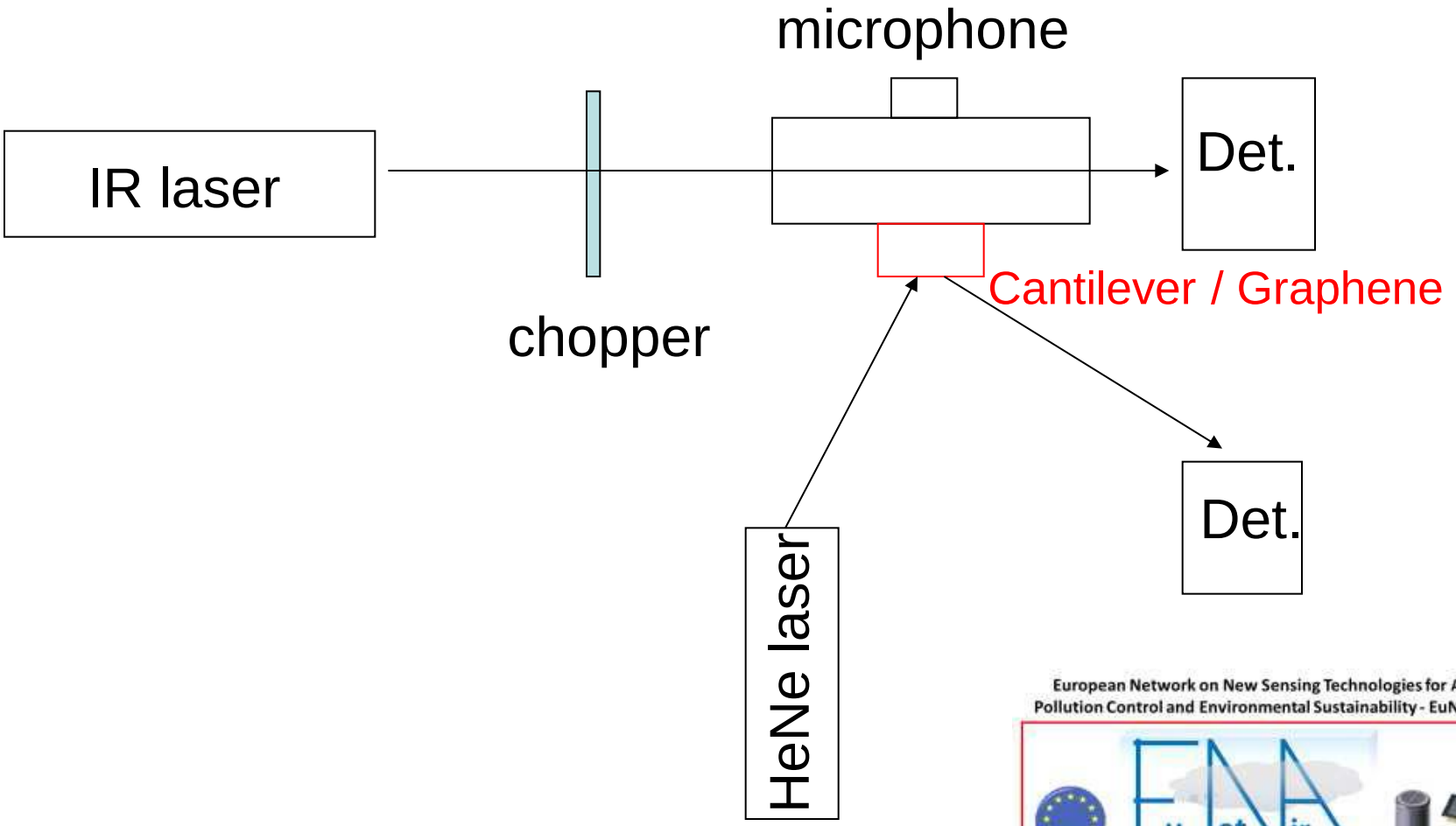
Experimental set-up



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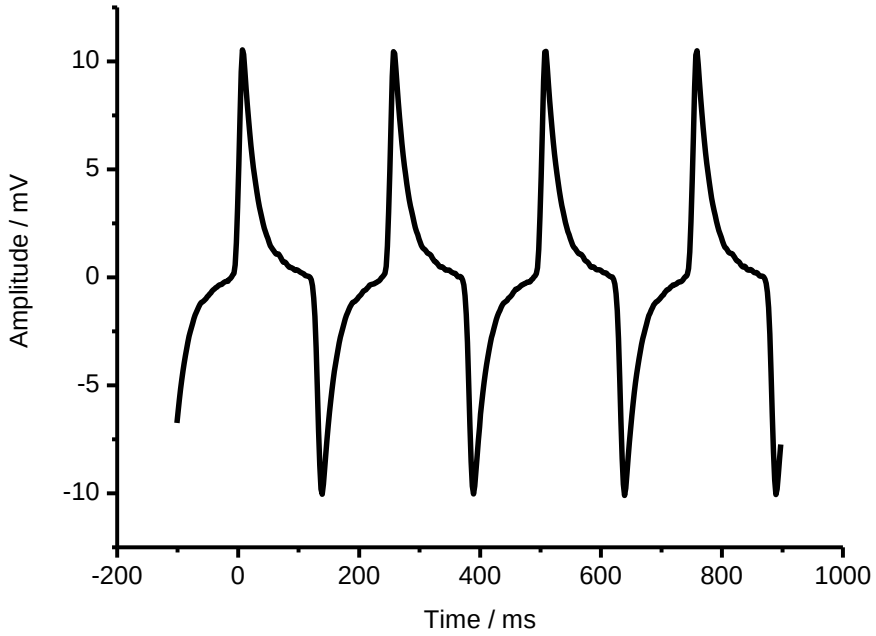
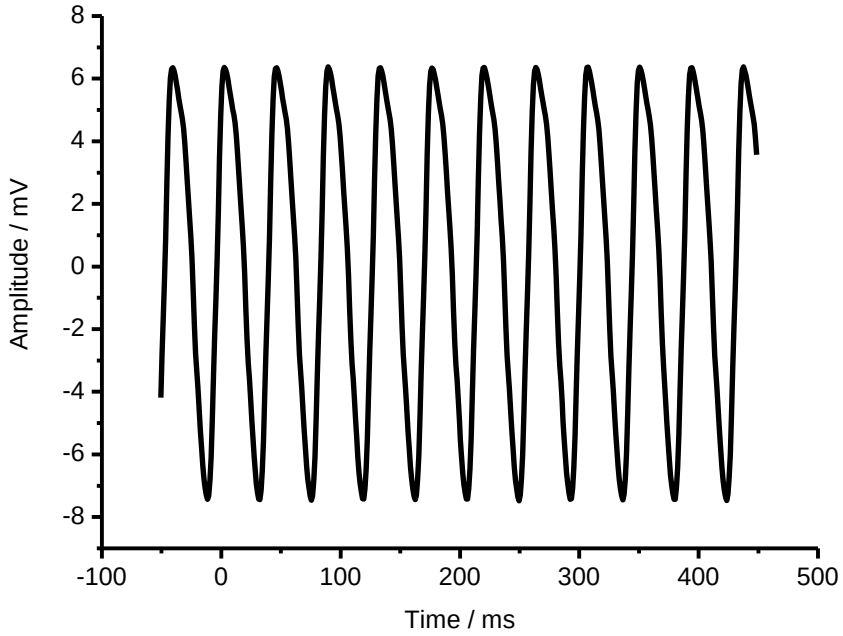
Detected MLG leafs movements



4 Hz



23 Hz

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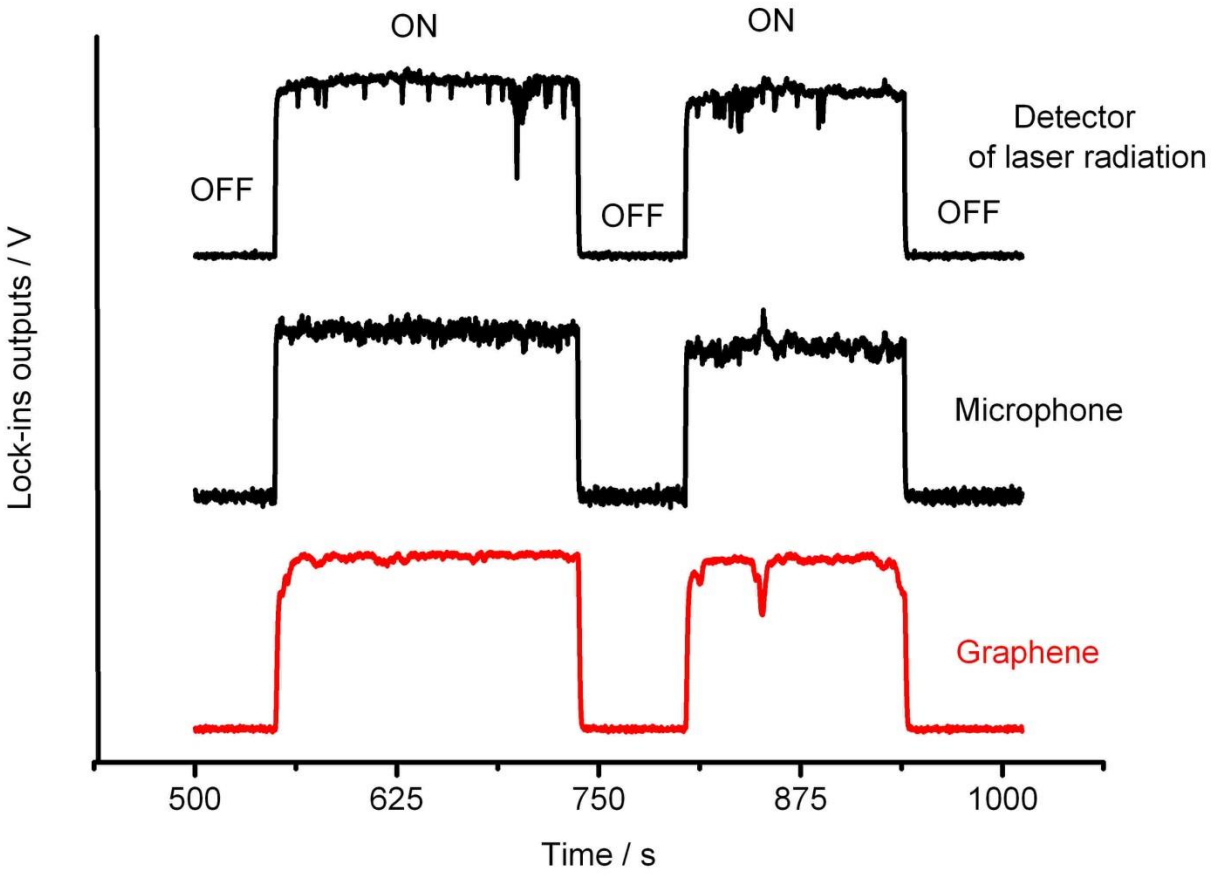
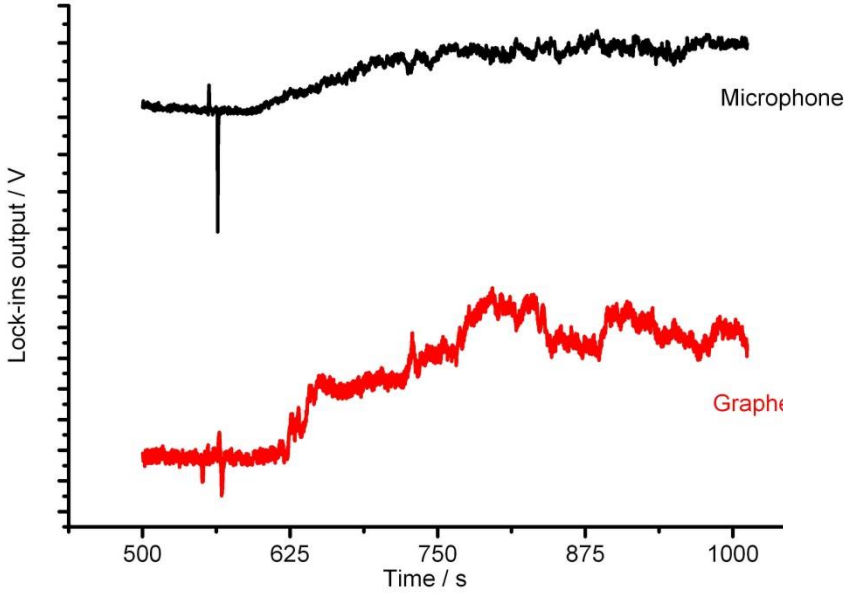
Comparison of the same concentration detection by microphone and graphene processed by lock-ins – laser radiation is ON or OFF



Sensitivity levels of the investigated experimental set-ups have been tested by the utilizing of the concentration standards based on the permeation method in the flow regime.

ON and OFF concentration (~2 ppm) for microphone and graphene detection:



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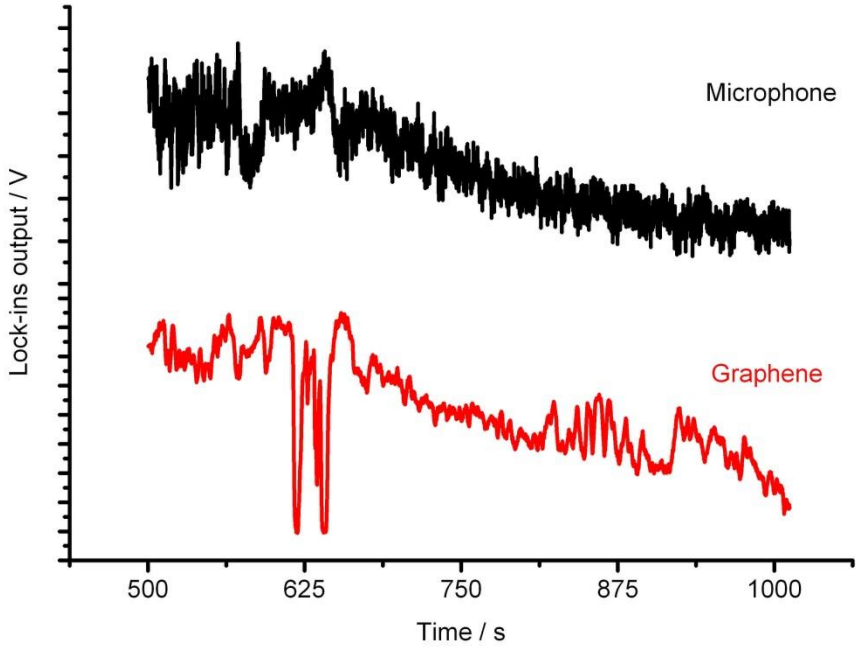

- silicon cantilevers and multilayer graphene (MLG) leafs as photoacoustic detectors.

- future:

  few-layer graphene (FLG) cantilevers/membranes, prepared by CVD technique and transferred to support, allowing free-standing mounting.

Many thanks for your attention!

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