# **Detection of the photoacoustic signal by an unconventional technique**

***Mustapha MABROUKI***

Photoacoustic (or optoacoustic1,2) refers to the generation of mechanical waves in an object illuminated by electromagnetic radiation. The first to report the existence of such a phenomenon was Alexander Graham Bell in 18803, who discovered that sound waves could emanate from objects illuminated by sunlight.

Little progress was made before the 1970s because of the lack of a usable light source and it was only with the rise of the laser that the photoacoustic effect came out of the shadows3. From then on, scientists saw its interest, in particular for biophysics and even medicine.

On the other hand, the discovery of atomic force microscopy (AFM) 4 was followed by a significant interest in the study of the physical, chemical and mechanical properties of materials.

Initially AFM designed for imaging with atomic and molecular resolution has now been combined with other techniques to give rise to other applications such as (PFM) pulsed forced microscopy) 5, (CFM) chemical force microscopy (chemical force microscopy) for the determination of functional groups6, as well as magnetic force microscopy to image magnetic dissipation7, and again near-field optical microscope (SNOM) scanning for imaging local optical properties8,9. Note also the acoustic force microscopy imaging (SAFM) 10,11,12 which makes it possible to analyze the propagation of the transverse acoustic wave with a submicron resolution as well as the UFM ultrasonic force microscopy 13 in the determination and measurement recently the contact stiffness of a thin film on a silicon substrate14. Studies combining SPM in general and acoustic waves15 directly have made it possible to locally measure the viscoelasticity of samples beyond the surface. Specifically those who combined STM measurements and the effect of laser light on the tip (expansion heating) and its impact on the measured STM signal. Finally the work done by U. Rabe and al 16 modifying the classic AFM to image a silicon surface and using an acoustic excitation generated by a transducer. This work allowed them to achieve lateral resolutions of the order of 100 nm for an excitation frequency of 20MHz..

The interest of this course is focused on the detection of acoustic and thermal waves and more precisely the detection of manometric deformations within a solid by combining the two techniques presented previously, namely AFM and photoacoustic. The latter is based on the effect linked to the conversion of light energy into thermal energy during a non-radiative de-excitation of the sample and identifiable by pressure oscillations17 and which provides information on the properties of non-destructive materials. . Note that this technique remains limited by the need to use a closed cell for the detection of the photoacoustic signal. This coupling of AFM and pulsed PA in our case made it possible to take measurements in air with a much wider temporal resolution

1 Gusev V.E., Karabutov A.A., Laser Optoacoustics, American Institute of Physics 1992

2 Beard P., Biomedical photoacoustic imaging, Interface Focus 1 602-603 (2011)

3 Li C., Wang L.V., Photoacoustic tomography and sensing in biomedicine, Phys. Med. Biol. 54 (2009) R59–R97

4 G. Binning, C. F. Quate, C. H. Gerber, Phys. Rev. Lett. 56, 930 (1986).

5 P.Mainvland. H.J. Butt, S.A.C. Gould, C.B. Prater, B.Drake, J.A. Gurley V.B. Elings, and P.K. Hansma, Nanotechnology 2,103(1991).

6 C.D. Frisbie, L.F. Rozsnyai, A.Noy, M.S. Wrighton, and C.M. Lieber, Science 265, 2071(1994).

7 P.Grutter, Y.Liu, P.Leblanc, and U.During, Appl. Phys. Lett. 71, 279(1997)

8  H-U. Krotil, T. Stifter, H.Waschipky, K.Weishaupt, S.Hild, and O.Marti, Surf.Interface Anal. 27, 336 (1999).

9 O. Kolsovo, and K. Ymanaka, Jnp. J. Appl. Phys. Part 2. 32, L1095(1993).

10 P, Vairac and B. Cretin, Appl. Phys. Lett. 68,461 (1996).

11 G.Behme, T. Hesjedal, E.Chilla, and H.J. Frohlichh Appl. Phys. Lett. 73,882 (1998).

12 W.Rohrbeck and E. Chilla, Phys. Status Solidi A131, 69(1992).

13 K.Yamanaka, H.Ogiso, and O. Kolosov, Jnp. J. Appl. Phys. 33, 3197(1994).

14 K.B.Crozier, G.G.Yaralioglu, F.L. Degertekin, J.D.Adams, S.C.Minne Appl. Phys. Lett. 76,1950(2000).

15 J.M. KIM,and S.M.Chang, Appl. Phys. Lett. 74, 466(1998).

16 U. Rabe and W. Arnold, Appl. Phys. Lett. 64, 1493(1994).

17 L.C. Aamodt, J.C. Murphy, J. Appl. Phys. 49, 3036 (1978).