Proceedings of Symposium on Ultrasonic Electronics, Vol. 30 (2009) pp. 211-212
18-20 November, 2009

Amplitude and phase of photo thermal signal in a leaf of plant “ scheffelera arboricola ” measured by PVDF sensor

PVDF センサーによる植物カポックの葉における光熱信号の振幅と位相の測定

Yoshiaki TOKUNAGA , Masatoshi YOSHIMURA ,Koji AIZAWA and Junji HIRAMA
(Graduate school of electric engineering and electronics ,KIT)
得永嘉昭 ， 吉村政俊 ， 會澤康治 ， 平間淳司 (金沢工業大学大学院)

1. Introduction

Recently, research on photosynthesis of a plant is becoming very important one from serious problems of CO_2 increment, and food depletion crisis. This research is also very interesting one to sonic and ultrasonic investigators. Phenomena of photosynthesis must be analyzed from two aspects which are a microscopic view point and a macroscopic one. In microscopic research interaction of photon, phonon and electron in plant organization plays fundamental and important roles. On the other hand, introduction to concept of a complex system with dispersive structure may be important from a viewpoint of macroscopic approach.[1] We have study thermal radiation for a thermal damage protection in process of photo-synthesis of plant “scheffelera arboricola (hereafter called kapok)” using PVDF sensor when light of dye laser with selected wave length is irradiated locally on various positions at top of a leaf.[2] In this paper we show results of amplitude and phase of photo thermal signal (hereafter called PT signal) from top or back of a leaf measured by PVDF sensor.

2. Photosynthesis in a leaf

First of all, we describe schematically photosynthesis in a leaf. **Figure 1** shows a schematic diagram of physical phenomena in the case of irradiation of sunlight to top surface of a leaf. Green light (around 550nm) composing of the sunlight may be passed thought a leaf since it is not used as an energy for photosynthesis. On the other hand, the red light (around 650nm) composing of the sunlight is used effectively as energy for photosynthesis[3] If irradiation energy to the leaf is so rich, the leaf may be radiated heat from it in atmosphere in order to prevent thermal damage caused by excess energy except energy used to do photosynthesis.

3. PVDF sensor for detecting PT signal

We are interesting to detection method of heat radiated from a leaf by PVDF film. In our experiment, the pyroelectricity of the PVDF film was mainly used although this film has both pyroelectricity and piezoelectricity.

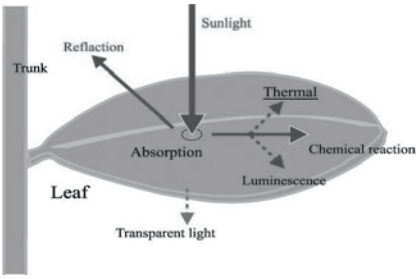


Fig.1 Physical phenomena by sunlight irradiation

Figure 2 shows schematic diagram on two kinds of PVDF film sensors made for detecting PT signal in a leaf. One is used for measurement of the PT signal radiated from top of the leaf and another for measurement of PT signal radiated from back of the leaf . PVDF sensor for top was formed transparent window (5mm diameter) in center area of the metal electrodes contacted to both sides of PVDF film, light of laser irradiated at this portion can pass through it without any absorption. The PVDF sensor for back, however, was covered perfectly film by metal electrodes. Contact of a leaf with the PVDF sensor was done directly without any adhesive agent.

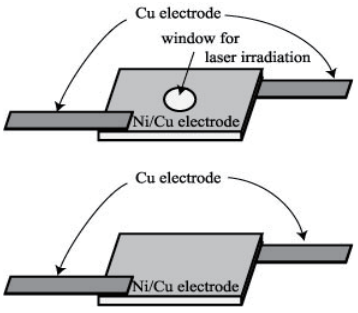


Fig.2 Two kinds of PVDF film sensors

toklab@mlist.kanazawa-it.ac.jp

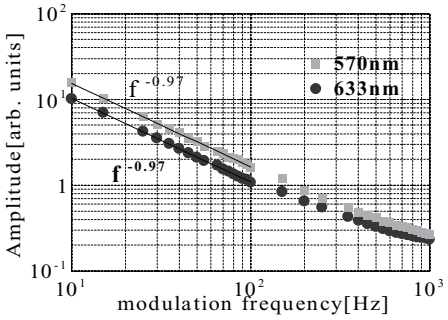
4. Experimental results and discussion

In order to confirm weather or not photosynthesis is caused in a plant, light of 570 or 633nm is irradiated to a leaf.

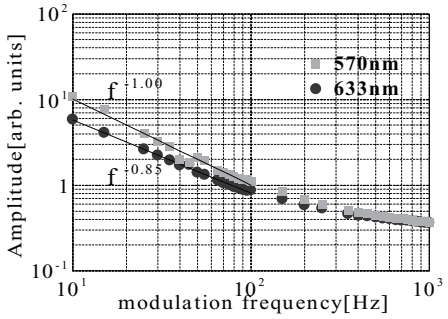
Therefore, as already known, light with 633nm is effective to the photosynthesis of plant and light with 570 nm, however, is not effective.

Figures 3(a) and (b) show modulation frequency dependence on amplitude of PT signal measured in top and back of the leaf when light with 570 or 633 nm is irradiated on the top. It was found that frequency dependence of the amplitude of PT signal in the top were -0.97 in ranging from 10 to 1000Hz. On the other hand, frequency dependence of the amplitude of PT signal measured in the back were -1.06 at 570 nm irradiation and -0.83 at 633 nm irradiation in ranging from 10 to 100Hz. This deviation seems to be due to photosynthesis of the leaf.

Figures 4(a) and (b) show phase of PT signal from top and back. In Fig.(a) it was found that small phase difference between irradiation with 570 and 633 nm in ranging from 10 to 100Hz was measured. In Fig.(b) phase delay of PT signal in 633nm irradiation was larger than that of the case of 577 nm irradiation in ranging from 10 to 100Hz. We consider that this deviation depends on lapse due to current of process converted chemical energy from photon energy irradiated to leaf.

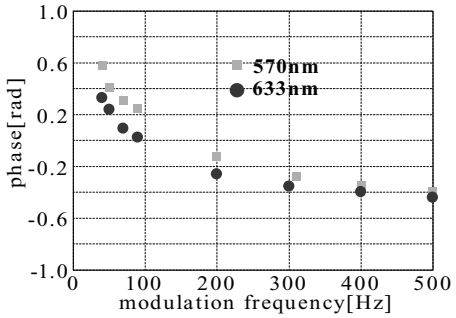


(a) Case of top detection

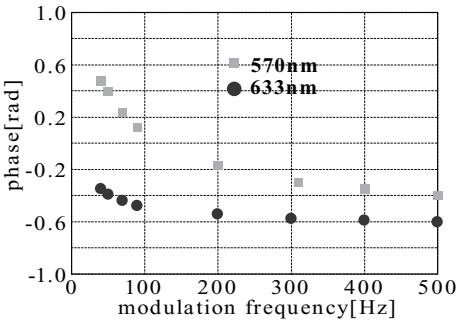


(b) Case of back detection

Fig.3 Amplitude of PT signal



(a) Case of top detection



(b) Case of back detection

Fig.4 Phase of PT signal

5. Conclusion

In this paper we described experimental results of amplitude and phase of PT signal from top or back in a leaf of plant "scheffelera arboricola" measured by PVDF sensor. Remarkable facts were as following**:** Frequency dependence on the amplitude of PT signal in top was -0.97 for 570 and 633 nm in ranging from 10 to 1000Hz.

On the other hand, frequency dependence on the amplitude of PT signal in the back were -1.06 at 570 nm irradiation and -0.83 at 633 nm irradiation in ranging from 10 to 100Hz. Phase delay of PT signal in 633nm irradiation was larger than that of the case of 577nm irradiation in ranging from 10 to 100Hz.

References

1) Y.Tokunaga et. al.: IEICE Tech. Report US2008-73 (2009-1) 7. [in Japanese]
2) Y. Tokunaga et. Al.: Proc. Symp. Ultrason. Electron. **29** (2008) 153.
3) K. Masuda: Photosynthesis education team of Univ. of Tokyo, Univ. of Tokyo press (2007) 66. [in Japanese]