

“*In vivo*” measurement of photothermal signal detected from a living or a death leaf of Kapok

生きている葉と死につつある葉からのレーザー誘起熱信号の” *in vivo*” 計測

Yoshiaki Tokunaga¹, Masatoshi Yoshimura^{1,2}, Akiko Ujiie², Junji Hiram¹ (¹Kanazawa Inst. Tech., ²Kanazawa Technical College)

得永 嘉昭¹, 吉村 政俊^{1,2}, 氏家 亮子², 平間 淳司¹ (¹金沢工大, ²金沢高専)

1. Introduction

Photoacoustic and photothermal spectroscopy have been used to study physical and thermal characters of non-organic materials such as single crystal, ceramics and others. These methodologies were not only very simple but also so effective and valuable ones. We have also used handmade SPAM to both microscopic and spectroscopic investigation. Therefore as microscopic investigation subsurface drill hole imaging in carbon, surface crack in mashinable ceramic were imaged¹⁾ In addition, as spectroscopic example, thermal diffusivities of PVDF films, adhesive and PET films such as commercial PET bottles were estimated quantitatively.^{2,3)} In recent social request, we consider that it is necessary to make new system reformed our handmade microscope for “*in vivo*” measurement on photothermal signal of leaving leaf of plant due to photosynthesis. However, it is difficult to perform with direct way of conventional methodology which has been already done because plant corresponds upon complex system and obeys always to rule of life arrow (time irreversibility) relating with energy dispersive process. In this paper we report a system for “*in vivo*” measurement and PVDF film transducer for detection of thermal signal radiated from leaving leaf of a plant “*schefflera arboricola* (Kapok)”.

2. Experimental system

Figure 1 shows schematically our experimental system. Dye laser pumped by Ar ion laser can be changed continuously from 570 nm to 640nm was irradiated on only small position of surface of leaf. The Kapok was put in a container of dark atmosphere. The spot diameter at the leaf surface was typically 3.0mm. For living or cutting leaf of the Kapok, the PVDF film transducer was used as a sensor since its acoustic impedance equals nearly to those of organisms

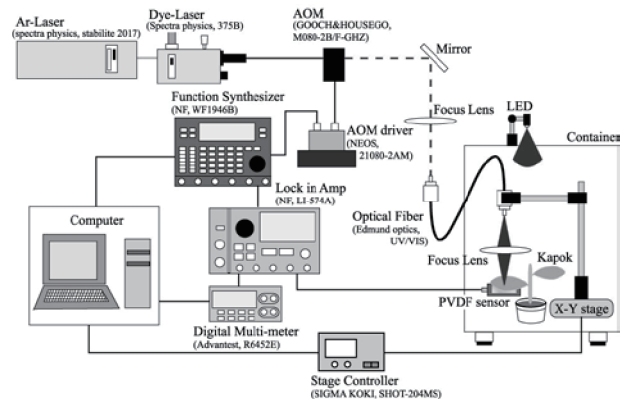


Fig. 1 Experimental setup

3. Experimental results

Figure 2 shows a photograph of the Kapok. Figure 3 shows a schema sensing photothermal signal of living leaf. The laser was irradiated on surface of the leaf through a circular window removed metal electrode in central region of a PVDF film. The irradiated energy can be reached on surface of the living leaf since the PVDF film has high transparency (more 90%) in visible wavelength. By cutting of the living leaf from trunk, temporal process toward death was investigated in a similar way with that of a living leaf experiment.



Fig.2. Photograph of a plant “Kapok”

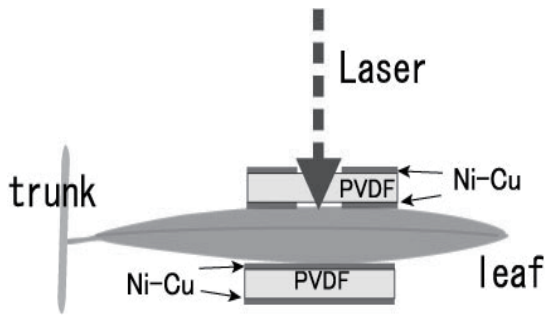
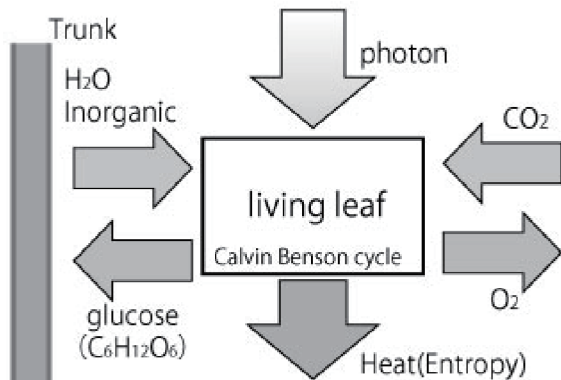
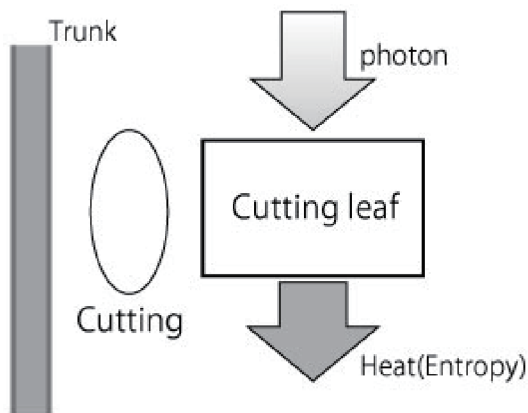


Fig.3. Detection of photothermal signals of living leaf by two PVDF film transducers

Figures 4(a) and (b) show essential difference of the living and the cutting leaves discussed from a pointview of complex system. In living leaf as shown in Fig. 4(a), the photosynthesis may be caused using H_2O and CO_2 mediated by laser energy. In this process, O_2 and heat (entropy) are radiated from stomata of the leaf. In the cutting leaf as shown in Fig. 4(b), on the other hand, the photosynthesis may be stopped because it cannot be gotten supplies of the H_2O and inorganic matters from the trunk.



(a) Living leaf

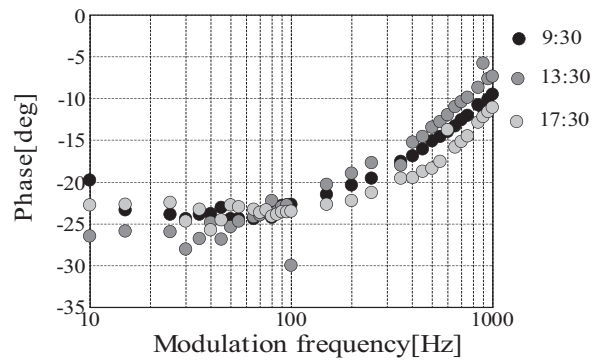


(b) Cutting leaf

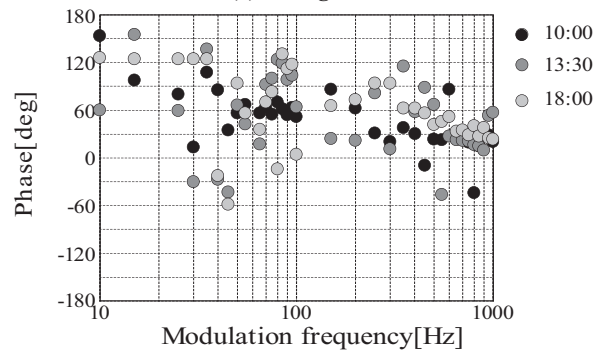
Fig4. Systematic explanation of the living and cutting leaves

Figures 5(a) and (b) show the phase of photothermal signals in the living and the cutting

leaves. Parameters mean measured times in a day. In the living leaf, the phases increase toward 0 degree with light modulation frequency in ranging from 10 to 1000 Hz. On the other hand, in the cutting leaf, dependence of light modulation frequency of the phases was just chaotic behavior. Clearly, it seems to be the phase transition from "order" to "chaos".



(a) Living leaf



(b) Cutting leaf

Fig.5 Phase of photothermal wave in the living and the cutting leaves

4. Conclusion

We describe experimental results on phases of photothermal signals of the living and the cutting leaves of Kapok.

References

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