In the middle of the fiber the corrected stress decreases to negative values. As the shear stress is the main part of stress components the value should go down to zero. The higher stress peaks show that the load on the fibers is higher than anticipated. The estimation of stress field and stress displacements especially in model samples will be much more accurate when both ways of evaluation presented above are combined.

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High Intensity Scanning Microscopy with a Femtosecond Cr:Forsterite Laser

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Accompanied by the improvements in ultrafast laser technology, there is a rapid advance in recent developments in high-intensity scanning microscopy. The primary advantage of this technique over laser scanning confocal microscopy derives from the confined excitation volume by using high-intensity-light induced multi-photon excitation fluorescence or high-order harmonic generation. This technique will not only provide a better z-axis resolution but also eliminate the need for a confocal pinhole[1]. The use of infrared excitation wavelength not only provides a deeper penetration depth but also avoids unnecessary out-of-focus photo-bleaching and photo-damages. However, the full potential of high-intensity scanning microscopy has not been realized due to the limited wavelength available in the market with a primary focus on Ti:sapphire lasers. Although this femtosecond source provides excellent images, comparative studies have shown that the Ti:sapphire wavelength is not optimized for penetrating thick biological tissues. An optimally penetrating optical source will take advantage of the diminishing scattering cross-section with wavelength, while avoiding the resonant molecular absorption of common tissue constituents such as water. In this paper we present a high-intensity microscopy technique by using a femtosecond Cr:forsterite laser source with a center wavelength of 1220–1240nm, which corresponds to the penetrating window in most biological tissues like human skin[2] and maize stem[3]. Other advantages of using the Cr:forsterite laser include that its two-photon fluorescence/second-harmonic-generation (SHG) falls in the red region and its three-photon fluorescence/third-harmonic-generation (THG) falls in the blue-to-green regions, which are visible and can be easily separated from the infrared pump-wavelength.

Like Ti:sapphire, Cr:forsterite is a broadband solid-state laser material tunable between 1167-1345 nm and is attractive for the generation of femtosecond pulse. Several hundreds miliwatts output power with pulses as short as 25 femtosecond have been produced from Cr:forsterite laser oscillators, which have been applied for optical coherent tomography[4] and transillumination imaging[5] of biomedical media, taking advantage of the high-transparency around 1250 nm. The laser constructed for this study uses a 19-mm-long Cr:forsterite crystal with a standard z-cavity and a semiconductor saturable absorber mirror. The laser is pumped with a 7W of 1064 nm light from a diode-pumped Nd:YVO_4 laser and produces 200 mW average output power with 130 fs pulsewidth tunable between 1220-1240 nm. Figure 1 shows an example of the SHG scanning image and its corresponding THG image of a bulk GaN sample (bandgap around 365nm) with a 50-μm-diameter circular defect, with the femtosecond Cr:forsterite laser source at 1230 nm. While the intensity of the SHG signal at 615 nm provides information on the strength of the strain-induced piezoelectric field, the intensity of the THG at 410 nm indicates the quality of interfaces. Figure 2 shows a photoexcited spectrum of a foliage leaf of *Epipremnum aureum* using the femtosecond Cr:forsterite laser. The sharp peak around 615 nm is SHG signal generated from bio-tissue interfaces and the broad peaks centered at 694 and 732 nm correspond to two-photon excited

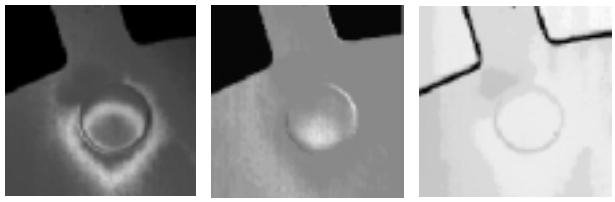

FIG. 1 Laser scanning microscopy images of a bulk GaN sample with a femtosecond Cr:forsterite laser. (a) Third-harmonic-generation image. (b) Second-harmonic-generation image. (c) Transmission image.

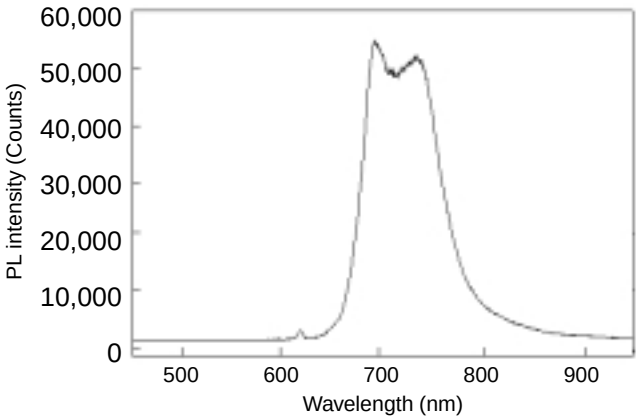

FIG. 2 Nonlinear PL spectrum of a foliage leaf of *Epipremnum aureum* excited by 1230 nm femtosecond light from a Cr:forsterite laser. The sharp peak around 615 nm is SHG signal and the broad peaks centered at 694 and 732 nm correspond to two-photon excited luminescence from chorophyll.

luminescence from chorophyll. We have also checked the luminescence from several widely used labeling dyes, including SYTO for nucleic acid stains, BODIPY TR for Amine-reactive probe, Alexa Fluor 594, Mitotracker, and Lysotracker. Excellent luminescent efficiency can be observed. Our study indicates that the Cr:forsterite laser can not only be an excellent substitute for Ti:sapphire lasers, but can also provide high penetration depth and information not available before. This project is sponsored by National Science Council of Taiwan R.O.C. though NSC 89-2215-E-002-004.

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Probe Microscopy

Polymer-Based Materials to be Used as the Active Element in Microsensors: A Scanning Force Microscopy Study

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Polymer based materials may be incorporated as the active sensing elements in a variety of microsensor devices. Most of these devices take advantage of the fact that certain polymers will either expand or contract when exposed to various analytes. In order for this response to be measured, many devices incorporate a conducting material such as carbon-black within the nonconducting polymer matrix. This composite material is then deposited on some type of electrode configuration. In response to analytes, polymer expansion or contraction results in a measurable change in the conductivity of the polymer/carbon composite material. Arrays of these sensors may be used in conjunction with pattern recognition techniques for purposes of analyte recognition and quantification.[1] We have used the technique of scanning force microscopy (SFM) to investigate microstructural changes in the carbon-composite polymers PVA, PEVA, and PIB when exposed to the analytes hexane, toluene, water, ethanol, and acetone.

Using phase-contrast imaging, changes in the carbon nanoparticle distribution within the polymer matrix were measured as the polymers were exposed to the analytes in vapor phase. Changes in the surface area percentage of carbon within the composite material ranged from -21.37 % to 37.1 % for PVA, -8.9 % to 47.6 % for PEVA, and -95 % to 89 % for PIB. In most cases, the changes were reversible upon removal of the analyte vapor.

The carbon black organic polymer composites suffer from a number of problems. First, it is difficult to reliably reproduce the performance characteristics of a given set of chemiresistor elements due to uncontrollable variations in composite construction. Also, spin-coated or drop-coated carbon-black polymer composites are inherently metastable in nature and may change or degrade with time. These composite systems may not reliably adhere to a substrate surface. Repeated exposure of the metastable sensor element to analyte vapor may lead to annoying or misleading changes in performance characteristics. Finally, the carbon in the composite material may slowly release analyte material following exposure to analyte and thus have a slow recovery time.

We have also tested a new type of microsensor based on piezoresistive microcantilever technology. In these devices, polymeric volume changes (when exposed to analyte vapor) are measured directly by a piezoresistive micro-