

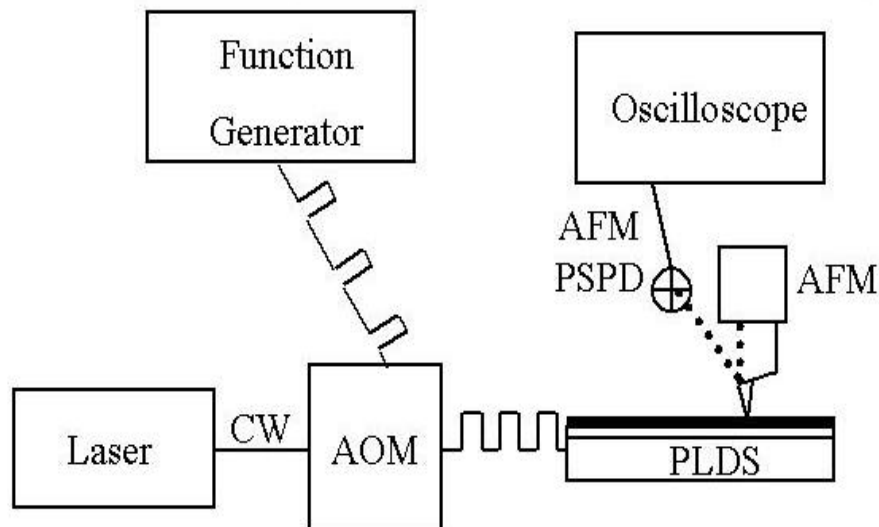
# **An Apparatus for Illuminating the Tip-Sample Interface of an Atomic Force Microscope**

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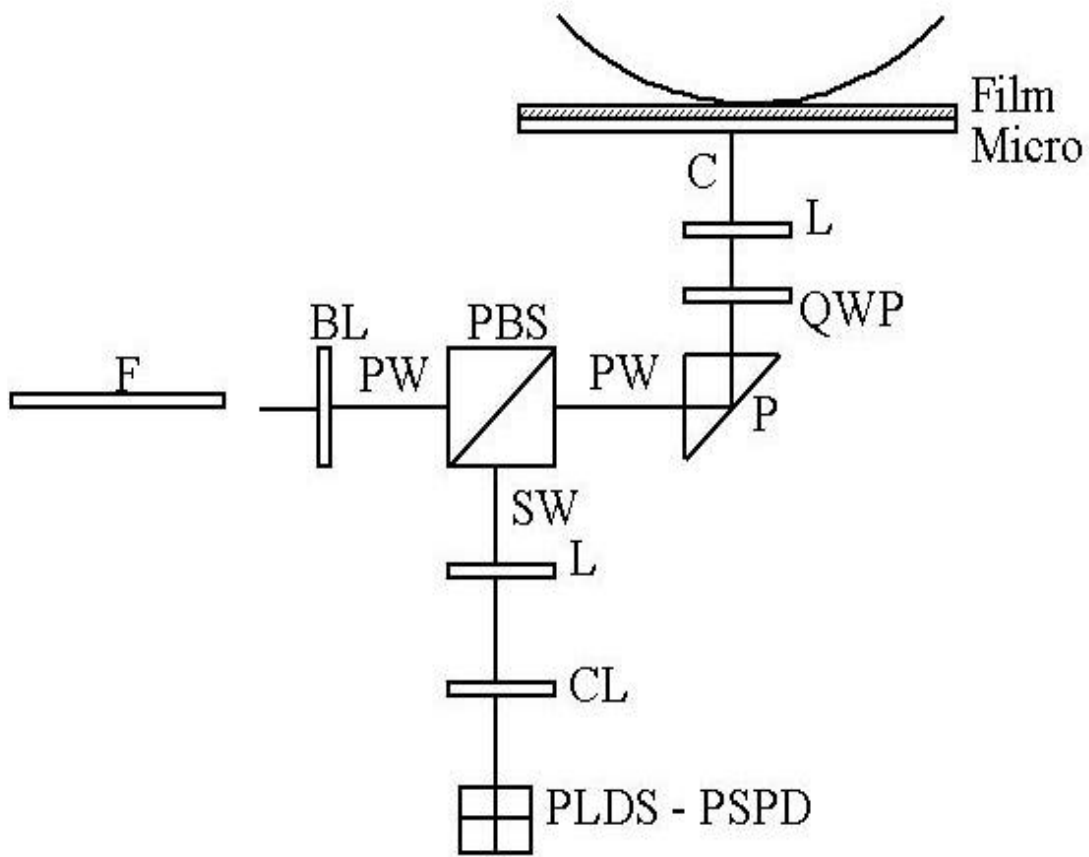
## **Abstract**

An apparatus for the delivery of radiation to the tip-sample interface of an Atomic Force Microscope (AFM) is demonstrated. The Pulsed Light Delivery System (PLDS) was fabricated to probe photoinduced conformational changes of molecules using an AFM. The system is 67 mm long, 59 mm wide, and 21 mm high, leaving clearance to mount the PLDS and a microscope slide coated with a thin film of photoreactive molecules beneath the cantilever tip of a stand-alone AFM. The PLDS is coupled into a fiber pigtailed Nd:Yag frequency doubled laser, operating at a wavelength of 532 nm. The radiation delivered to a sample through the PLDS can be configured for continuous or pulsed mode. The maximum continuous wave (CW) power delivered was 0.903 mW and the minimum pulse width was 12.3  $\mu$ s (maximal 401  $\mu$ s), corresponding to a minimal energy of 0.150 nJ (maximal 362 nJ), and had a cycle duration of 10.0 ms. The PLDS consists of micro-optical components 3.0 mm and smaller in diameter. The optical design was inspired by the three-beam pick-up method used in CD players, which could provide a method to focus the pulse of light onto the sample layer. In addition, the system can be easily modified for different operational parameters (pulse width, wavelength, and power). As proof that the prototype design works, we observed a photoinduced 'bimetallic' bending of the cantilever, as evidenced by observing no photoinduced bending when a reflective-coated cantilever was replaced by an uncoated cantilever. Using the apparatus will allow investigation of many different types of molecules exhibiting photoinduced isomerization.

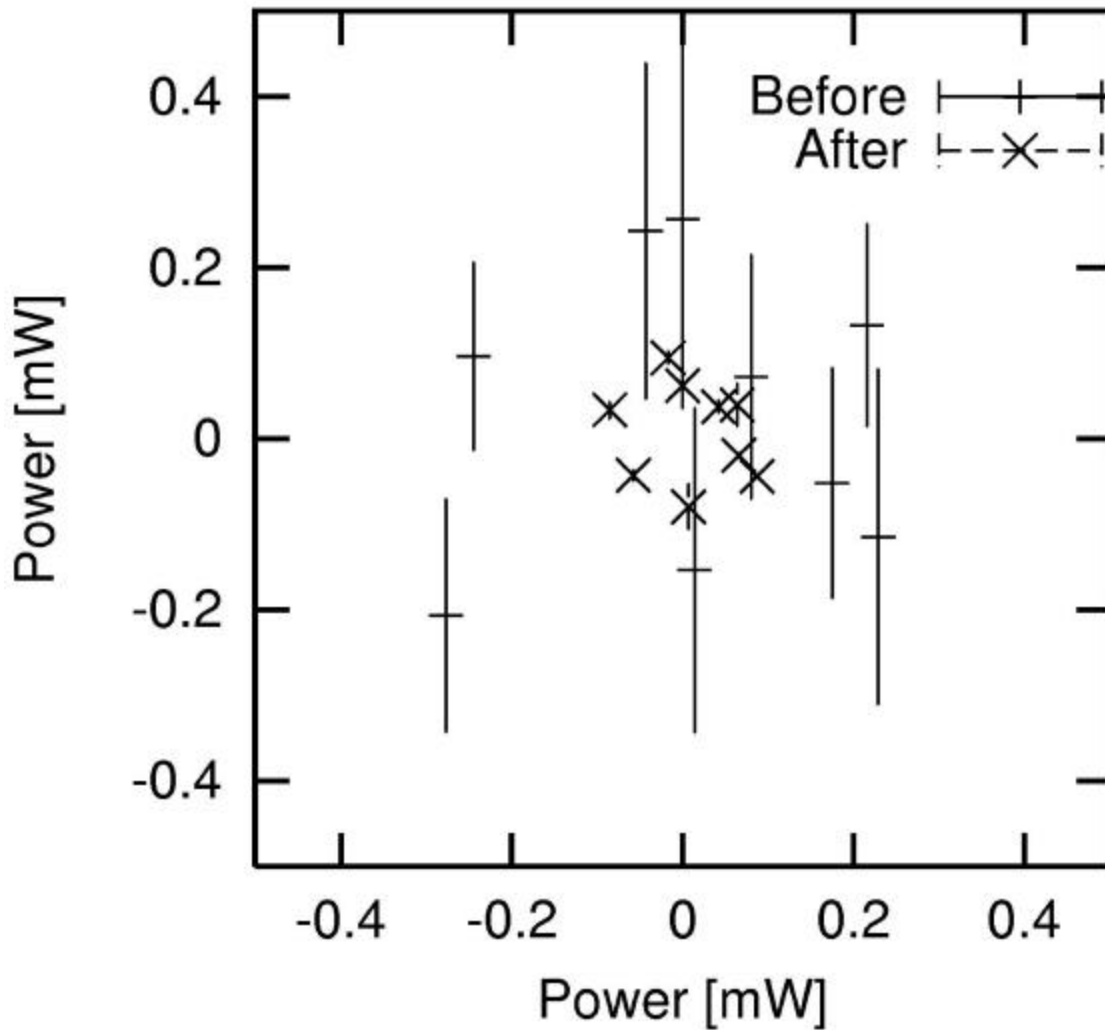
Location	Power Loss (dB)
Jumper Cable	0.7
AOM	2.5
Fiber cleave	2.3
PLDS	3.5



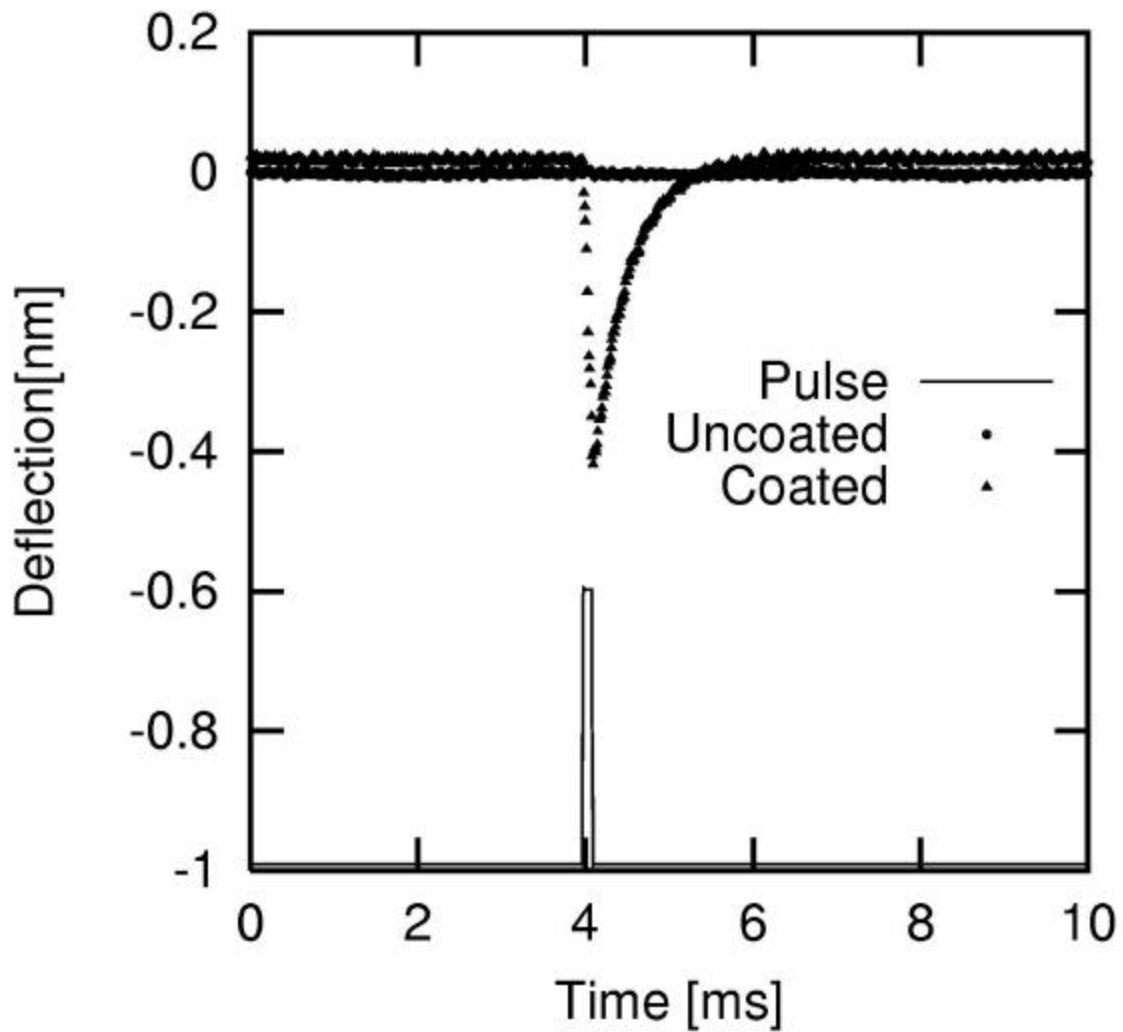
(1) Experimental arrangement. The laser ( $\lambda=532\text{nm}$ ) operates in CW mode. The AOM, connected to the laser via an SMF-28 jumper cable, turns on when the voltage is high and off when it is low. The function generator produces pulses with a 10 ms cycle time and delivers them to the AOM. The PLDS is connected to the AOM by an FC/APC connector. The PLDS delivers the light pulses to the shaded area, which is the sample, and the motion of the cantilever is detected by the AFM-PSPD. The oscilloscope reads the voltage from the AFM-PSPD (A-B signal) and records the average of 256 periods. As a note, the PLDS is able to fit within the AFM because the instrument scans the cantilever as opposed to the sample. The table indicates the amount of power loss at different points within the experimental set-up.



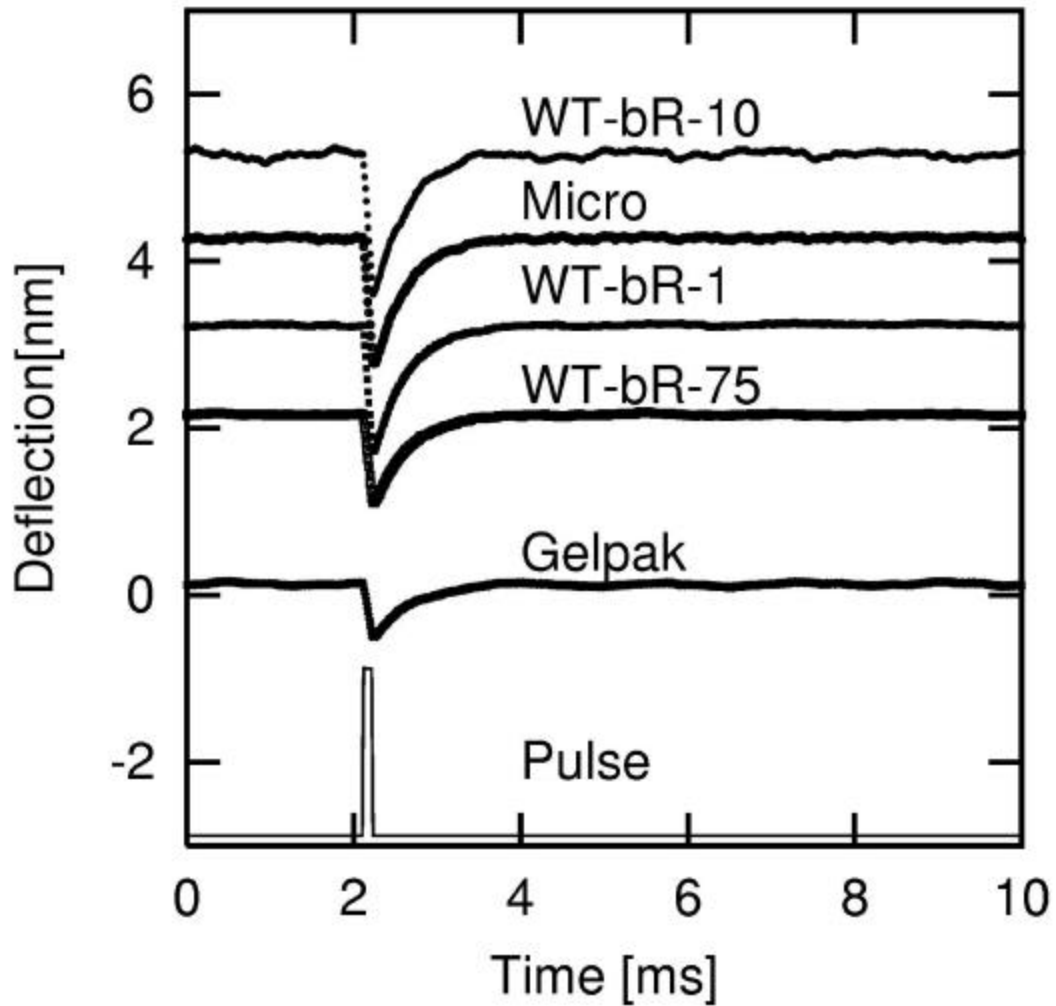
(2) The micro-optical components contained within the PLDS, which delivers the pulse of light. F=polarization maintaining single mode Fiber, BL=Ball Lens, PBS=Polarizing Beam Splitter, P=Prism, QWP= $\lambda/4$  Wave Plate, L=Lens, Micro=Microscope slide, L=Lens, CL=Cylindrical Lens, PSPD=Position-Sensitive Photodiode. The upper half of the micro-optical components is the first leg (F, BL, PBS, P, QWP, L, Micro). The lower half is the second leg (PBS, L, CL, PSPD). PW= transverse electric component of the electromagnetic field (parallel to the plane of incidence), SW= transverse magnetic component of the electromagnetic field (perpendicular to the plane of incidence), and C=Circularly polarized light.



(3) Polarization before and after realignment. The polarization was calculated by setting the power measurement at a given angle equal to  $R$  and the angle equal to  $\theta$ . Then, to create each data point  $X=R\sin(\theta)$  and  $Y=R\cos(\theta)$  were calculated. Notice that after realignment the polarization is much closer to circular, as desired.



(4) Demonstration of the bimetallic effect. The uncoated cantilever ( $k=0.30$  N/m) does not have the reflective aluminum coating, whereas coated cantilever ( $k=0.35$  N/m) does. The data were taken while the cantilever was hanging freely in air. Dividing by 100 and then subtracting a small DC offset (0.05), the voltage pulse to the AOM becomes visible on the same graph as the cantilever deflection. Notice there is no cantilever deflection when the cantilever is uncoated.



(5) Photoinduced cantilever deflection and the input pulse to the AOM. The cantilever deflection data were taken while in contact with the respective sample. The cantilever deflection data were offset by a small DC value (increments of 0.05), in order to view the individual curves better. Dividing by 25 and then subtracting a small DC offset (0.1), the voltage pulse to the AOM becomes visible on the same graph as the cantilever deflection.