Application Note

030-AN-0024

Orientation measurement of polyethylene by polarized Raman spectroscopy

Introduction

A plastic string like on the right has the property of easily deformed in one direction, but strong in another direction. This is due to orientation of polymer molecular chains in a certain direction, increasing the physical strength. Similarly, the orientation of polymer materials such as films and chemical fibers is closely related to the functions and properties of the materials. Using polarized microscopic Raman spectroscopy, it is possible to measure the micron-ordered area with non-destructive and non-contact method to evaluate the orientation of the polymer*1.

Figure 1. IQ Frame

In this note, we introduce the results of the orientation analysis of a polyethylene string using a polarized microscopic Raman system and the IQ Frame.

Keywords

Raman spectroscopy, polarization, polyethylene, IQ Frame

Experimental

A polyethylene string was affixed on a metal plate and set in the IQ Frame*2. In the measurement, the analyzer was placed so the sample was parallel to the polarization direction of the incident light (laser), and the polarized Raman scattering parallel to the incident light was detected. The sample was rotated in 10o steps using the scale on the IQ Frame, and Raman spectra were obtained at each of the 36 points (total 360o) using the rotational alignment function of the IQ Frame.

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Rotational alignment function

After rotating the sample under the microscope, it is a challenge to align exactly at the same measurement position. The rotational alignment function mentioned in this note uses the image matching technology of the IQ Frame, and the measurement position can be aligned accurately and quickly even if the sample is rotated. It is especially effective when evaluating the orientation of a heterogeneous sample.

Example: Measurement after rotated 45°

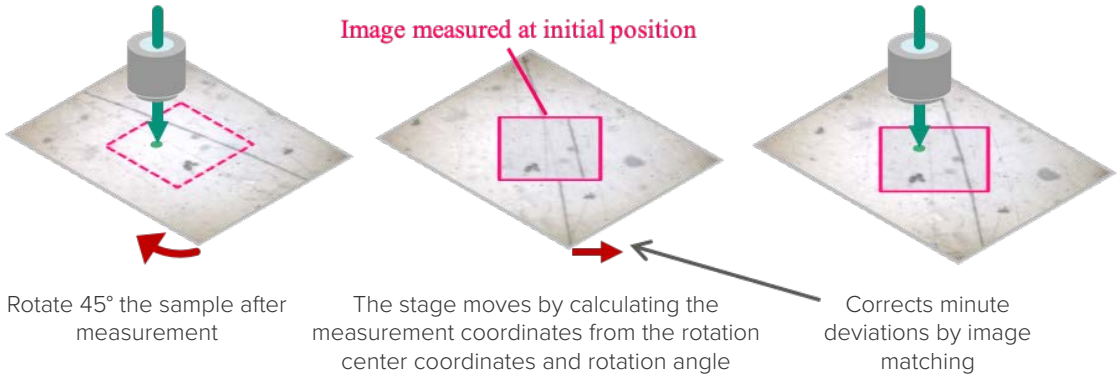

Figure 2. Image of rotational alignment function

Measurement Conditions: Raman Microscopic System	
Main Unit	NRS-4500 Raman spectrometer
Ex Wavelength	532 nm
Objective Lens	20x
Exposure Time	3 seconds
Accumulation	2 times

Figure 3. NRS-4500 Raman spectrometer

Results

First, it can be confirmed from the optical images shown in Figure 5 that the same point can be measured at each angle. As a result of obtaining Raman spectra by rotating the polyethylene string by 360°, changes were observed in the peak of C-C skeletal vibration indicated by the arrow in the spectrum of Figure 4. The peak of C-C skeletal vibration is closely related to the degree of orientation. From the results in Figure 5 in which the peak intensities were plotted for each angle, it was confirmed an 8-shaped intensity distribution with maxima at 0° and 180°.

Therefore, it was suggested that the polyethylene string measured was strongly stretched uniaxially in the laser polarization direction (horizontal direction on the paper) at 0° and 180°.

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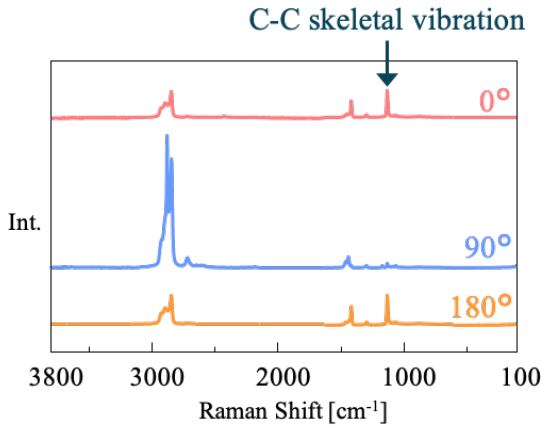

Figure 4. Each spectrum at 0°, 90°, 180°

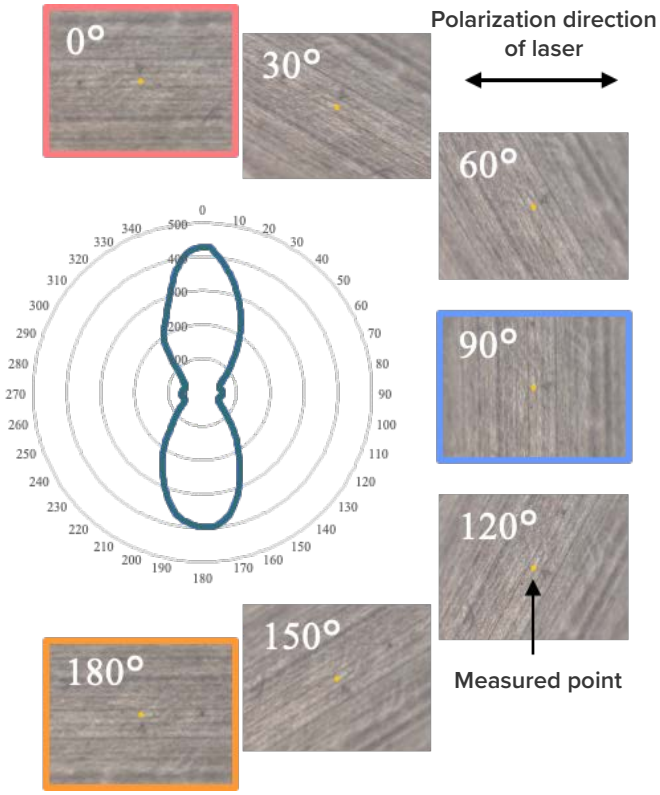

Figure 5. Peak intensities plot and observed image

Conclusion

Combining the polarized microscopic Raman system and the rotational alignment function of the IQ Frame, the orientation state of the polyethylene string was evaluated accurately. This combination could be used to evaluate the orientation of various polymer films and fibers such as polyethylene terephthalate and polypropylene.

*1 Raman Application Note: 210-AN-0019
*2 Raman Application Note: 210-AN-0016

System Configuration	Model	Description	Part Number
Main Unit	NRS-4500-532	Raman Spectrometer	7118-J051A
Options	RAP4-745	Automatic polarization measurement unit (0/90 degree switching)	6882-J501A
	SH02-RM	IQ Frame for Raman	7071-J137A

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