Characterization of PET preforms using spectral domain optical coherence tomography

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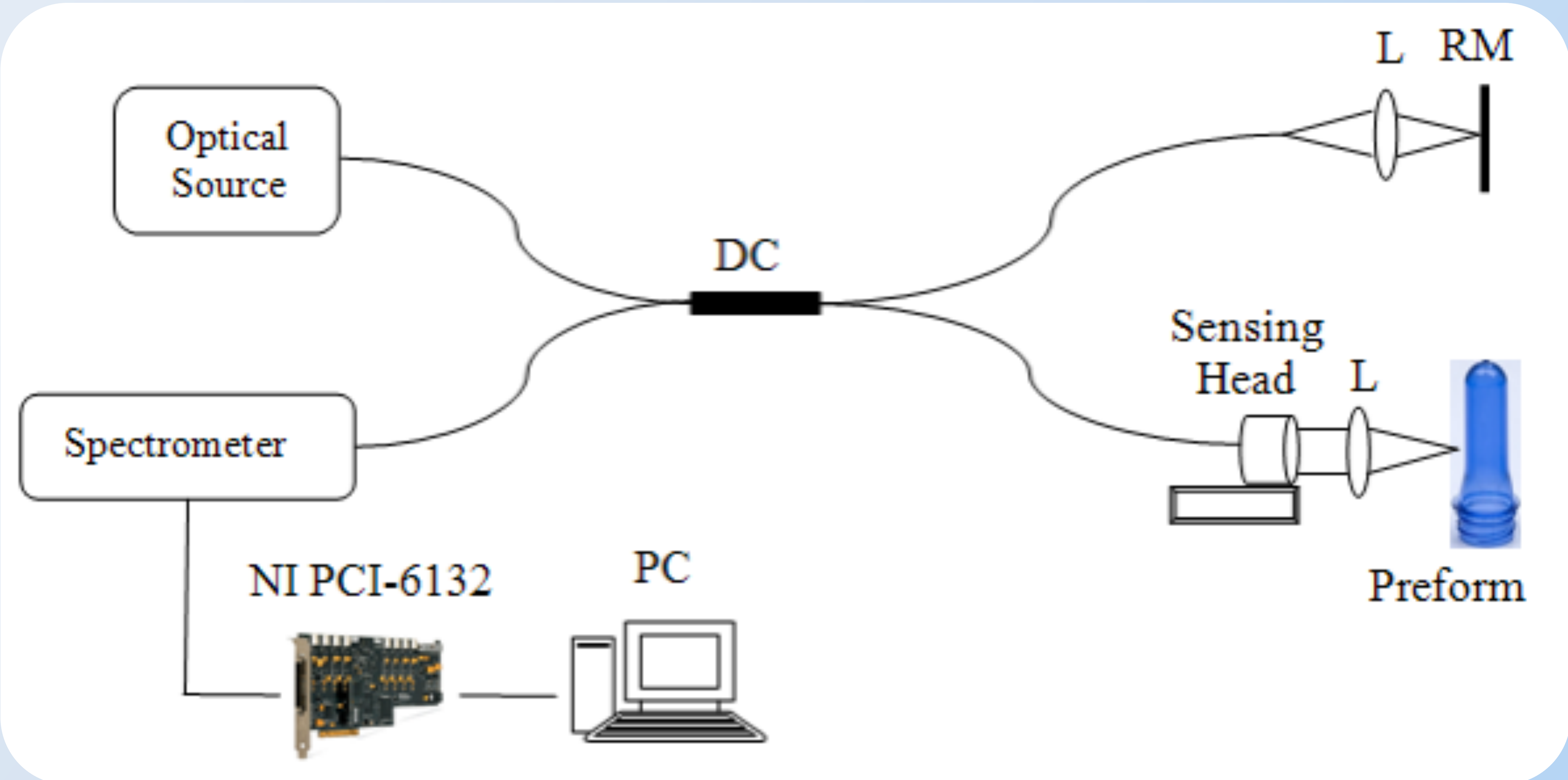
Abstract

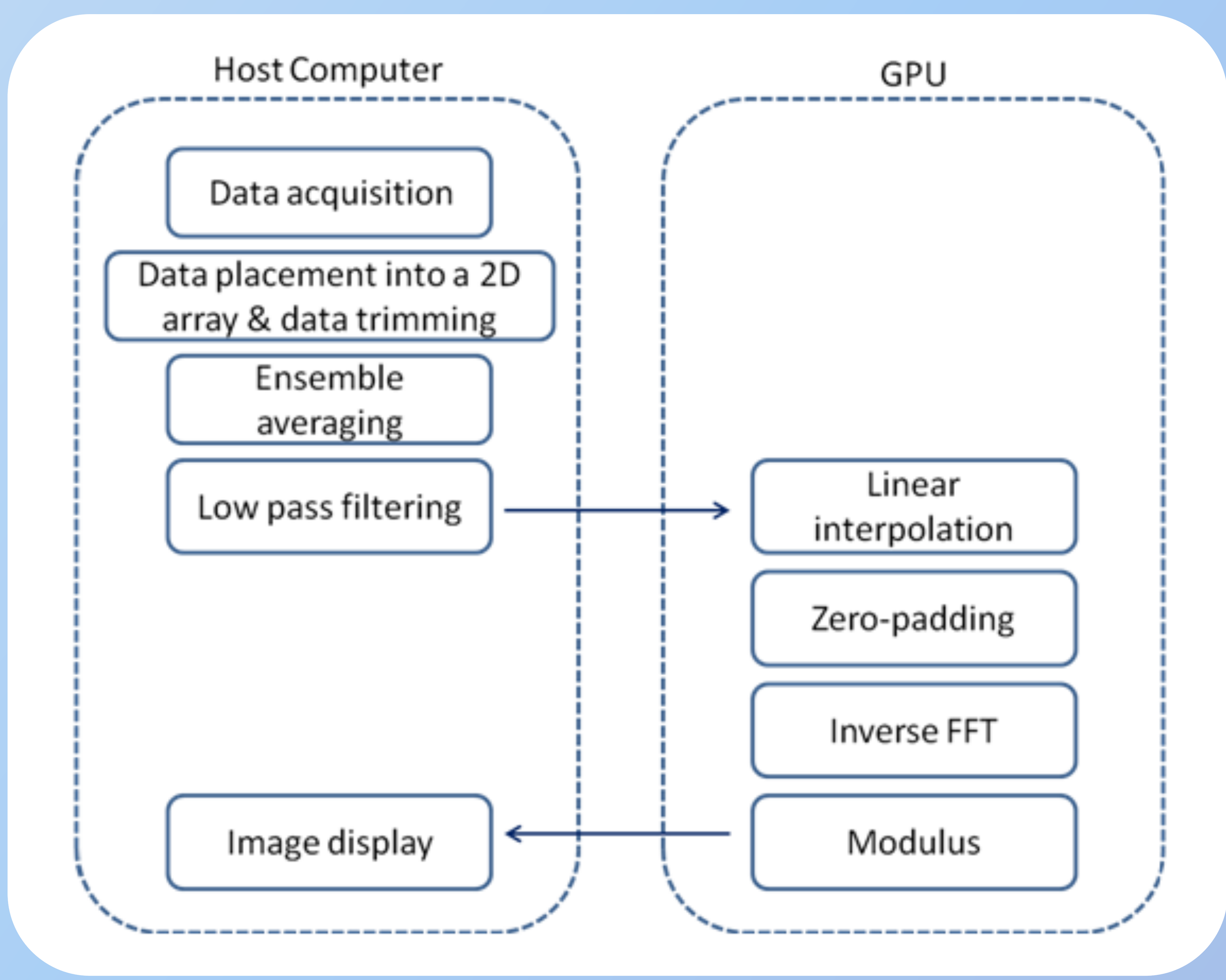
Polyethylene Terephthalate (PET) preforms are extensively used to produce plastic bottles because of its rigidity and high transparency properties. These preforms are manufactured as a laminate consisting of: (a) inner and outer layers of a polyester composed mainly of polyethylene terephthalate and (b) an intermediate layer, which is a very thin film placed between the inner and the outer layers. The intermediate layer plays the role of a barrier to lower the permeability. In present work, an approach based on spectrally resolved white light interferometry technique, spectral domain optical coherence tomography (SD-OCT), is proposed to precisely measure the thickness, within the range of micrometers, of the intermediate film layer. A non-destructive approach and all required signal processing steps to characterize the thin inner layers and also to improve the imaging speed are presented. The algorithm is developed by using graphics processing unit (GPU) with computer unified device architecture (CUDA). This GPU-accelerated white light interferometry technique non-destructively assesses the samples and has low cost and high imaging speed advantages, overcoming the bottlenecks in PET performs quality control.

Experimental setup



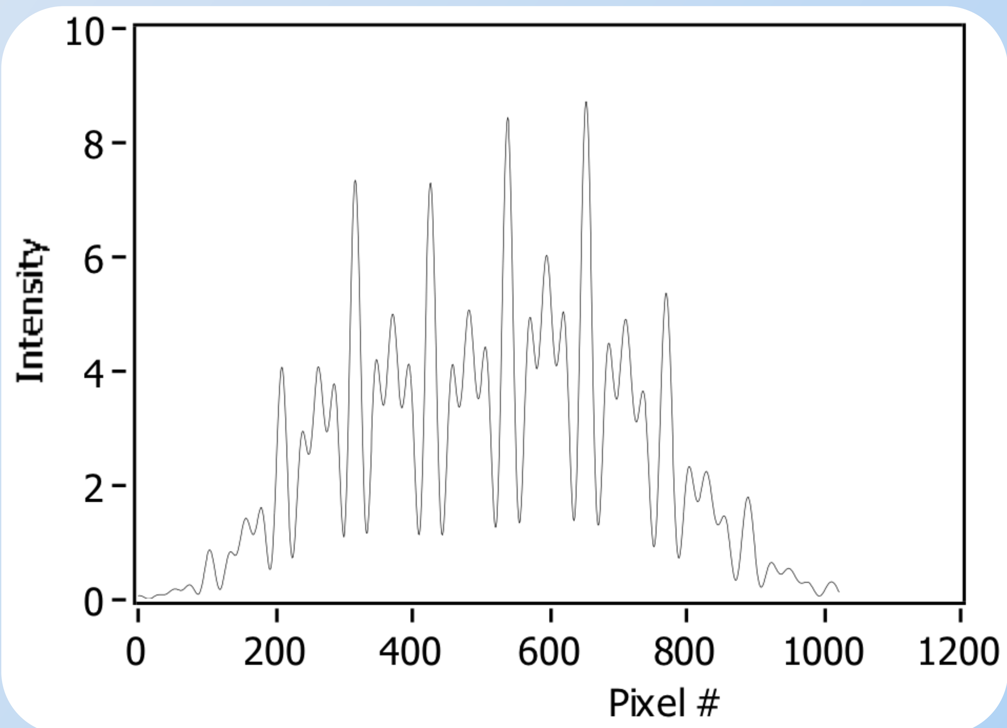
Optical source: Multiwave Photonics' Broadband ASE source (output power of 20 mW, FWHM = 90 nm and λ_0 = 1050 nm), DC: directional coupler, L: lens, RM: reference mirror.

Signal processing algorithm



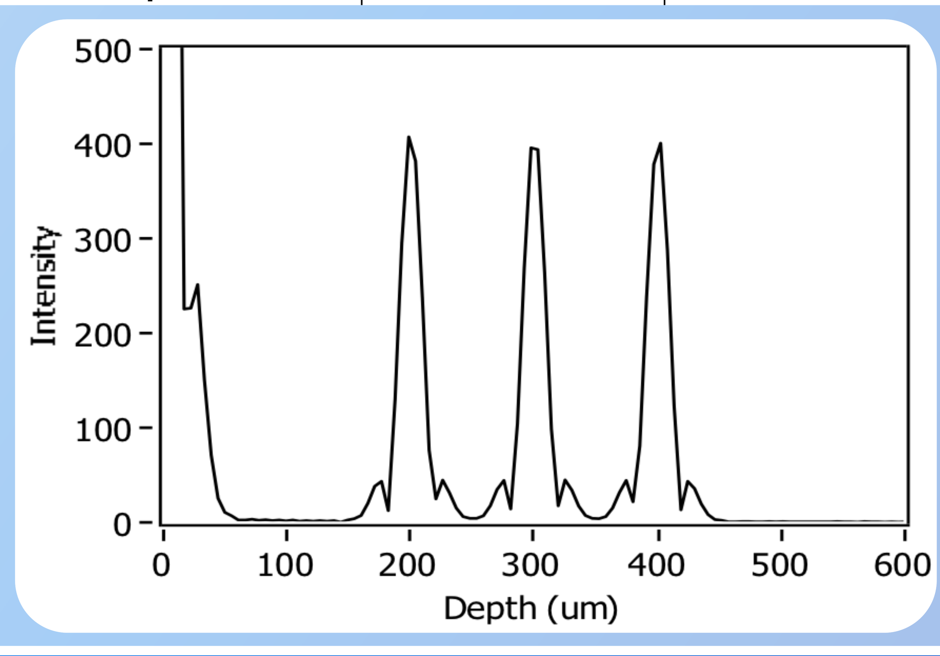
Signal processing steps performed in the host computer and GPU

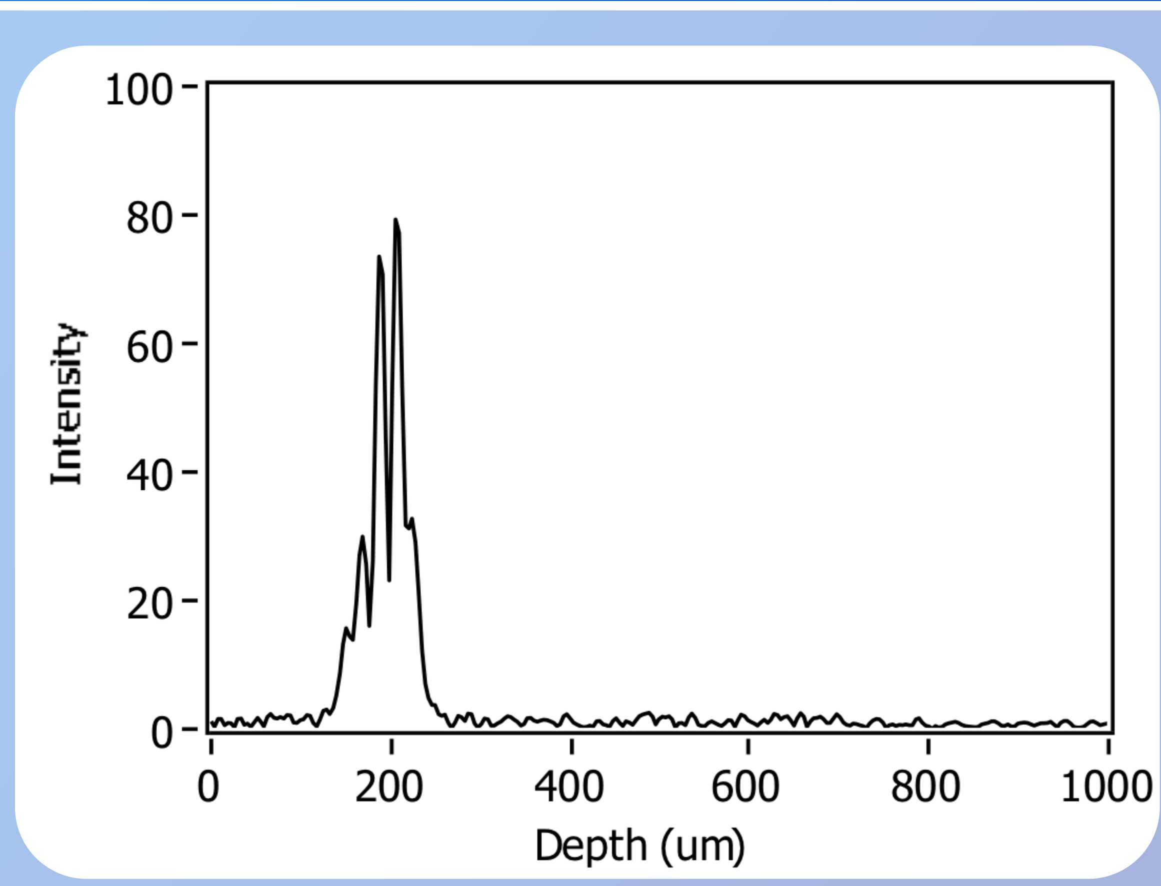
Results



The simulated photo-detected signal at three reflecting surfaces, z=200 µm, 300 µm, and 400 µm (above image) and the resulting reflectivity profile processed by host and GPU shown with calculated time execution results(right image and table).

	GPU	Total time (Host + GPU)
One A-scan	3.6 ms	3.7 ms
Image size of 512×1024 pixels	8.9 ms	70 ms
Image size of 1024×1024 pixels	16 ms	220 ms





The resulting depth profile obtained by imaging the thin inner layer of the preform. The thickness of 18.3µm (the distance between the two peaks) was acquired for the examined thin intermediate film layer.

Conclusions

In this study, a non-destructive approach to examine and measure the thickness of the thin intermediate layer(s) of preforms was demonstrated. The proposed approach was based on GPU-accelerated white light interferometry technique to non-destructively evaluate the samples. All required signal processing steps for this in-line measurement were illustrated. The devised solution has low cost and speed advantages over other approaches employed for quality control of the preforms at the production line.

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