Characterising the glass transition temperature of a thin film

Background

Polymers are a versatile and valuable category of materials, their properties often manipulated by varying their composition and molecular weight. As nanoscience and nanotechnology become increasingly important, the use of polymeric thin films is rapidly increasing also. The ability to use thin polymer films to change the surface or interfacial properties of a material is well established. However, the effect of constraining the polymer to nanoscale dimensions, particularly when those dimensions approach the radius of gyration of the polymer, have been reported [1], but are not fully understood. The effect this has on the properties and performance of the polymer film can be detrimental if not quantified. Often the difference in the glass transition temperature, T_g, of the polymer when present as a thin film, compared to the value for the bulk material, is used as a descriptor.

Objective

Characterise the glass transition temperature of a thin film of poly(methyl methacrylate) (PMMA).

Experimental

Using a UVISEL ellipsometer (Horiba Scientific, UK), incorporating a custom-built adaptor and heating stage [**Figure 1**], it was possible to measure the thickness of a PMMA film as a function of temperature. The film was deposited onto a Si wafer using a spin coater, from a toluenic solution. The adaptor served to ensure the heating stage was rigidly mounted on the ellipsometer stage. Minute vibrations and slight shifts in stage position would have been detrimental to the success of this technique.

Results

The thickness of the PMMA film as a function of temperature is shown in **Figure 2**. It can clearly be seen that at temperatures in excess of 130 °C the film expands with increasing temperature. For temperatures below 130 °C, the film is still in the glassy state, and hence there is minimal thermal expansion.

Figure 1. UVISEL ellipsometer modified with a custom adaptor, securely housing a high temperature heating stage

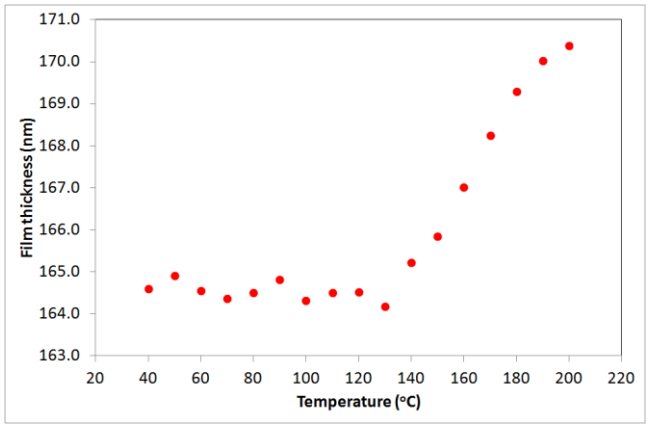

Figure 2. Thickness of a PMMA film as a function of temperature, showing T_g around 130 °C

References

1. Keddie, J.L.; Jones, R.A.L.; Cory, R.A.; Size-dependent depression of the glass transition temperature in polymer films, *Europhys. Lett.*, **1994**, *27*, 59-64.

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