Erratum: "Indentation responses of time-dependent films on stiff substrates" [J. Mater. Res. 19, 2487 (2004)]

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This article appeared in the August 2004 issue of *Journal of Materials Research*. The following corrections are required.

Section II. Experiments p. 2488
The third paragraph in the Experiments section should appear as follows:

One mechanism to explore changes in the shape of an indentation load-displacement response is to normalize the trace by its peak point. It has been demonstrated that the normalized [$h/h(P_{\mathrm{MAX}})$, P/P_{MAX}] experimental responses for bulk polymers indented at constant loading- and unloading rate with the same rise time (but at different peak load levels) are identical.[6] Figure 1(a) shows raw load-displacement data for indentation tests performed at small peak loads in the thickest polymer film (Epon) in the current study. The peak loads, 1 and 2 mN, were chosen to correspond to depths less than 10% of the film thickness in both cases. The responses normalize to the same shape [Fig. 1(b)]. When the 1-mN normalized response is compared with those from much greater load levels (50 and 500 mN), there are clear changes in the shape of the response, both loading and unloading [Fig. 1(c)]. In particular, the loading response shifts from slightly less than quadratic (power law fit with exponent 1.8) for the 1-mN response, as would be expected for a quadratic material with some creep effect; to a response between quadratic and cubic (power law fit with exponent 2.6) for the 500-mN response. The unloading response is also altered in shape, with a steeper unloading tangent at the larger load.

Equation 9, p. 2491
Equation 9 should appear as follows:

$$\begin{aligned} P_V &= \alpha_2 E' \tau_Q^2 \left(\frac{\mathrm{d}h_V}{\mathrm{d}t}\right)^2 \\ P_E &= \alpha_2 E' h_E^2 \\ P_P &= \alpha_1 H h_P^2 \quad . \end{aligned} \tag{9}$$

Figure 4, p. 2491

Figure 4 should appear as follows:

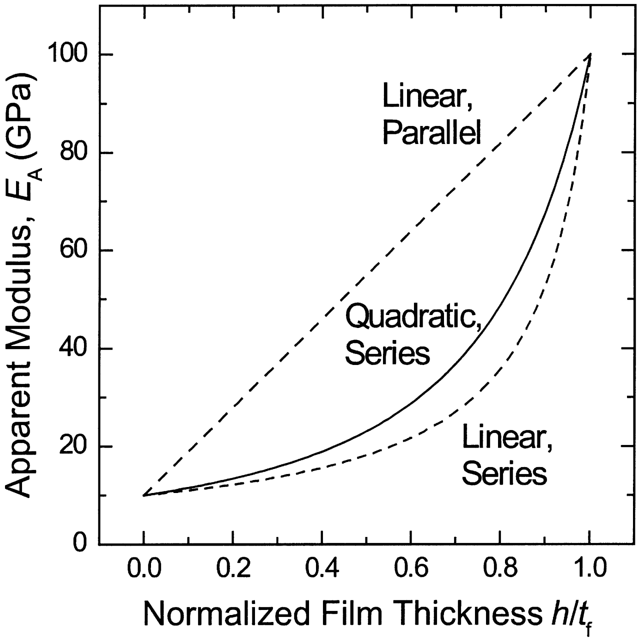

FIG. 4. Apparent elastic modulus as a function of the depth fraction $E_A(h/t_f)$ for series and parallel combinations of linear springs and series combination of quadratic springs with a depth-weighted modulus function (from Eqs. (3), (7), and (8) with $\upsilon = 0$). The two component moduli are assumed to be 10 GPa and 100 GPa.

Section V. Discussion, p. 2494

The first paragraph in the Discussion section should appear as follows:

The substrate-induced stiffening model accurately predicts changes in the shape of load-displacement ($P - h$) responses of a viscous-elastic-plastic material subject to elastic stiffening from the influence of a substrate. A set of load-displacement traces over a large range of peak load values can be predicted using five parameters: the film elastic (plane strain) modulus E'_f, the substrate (plane strain) elastic modulus E'_s, the film's resistance to plastic deformation H, the film's phenomenological time constant τ_Q , and a load level associated with the film-substrate interface, P_{intf}. Practical implementation of the model was performed in the current study by estimating properties for film (E'_f, H, τ_Q), substrate, (E'_s), and system (P_{intf}), based on the largest and smallest peak loads from a series of indentation tests performed at constant loading- and unloading rate. Intermediate responses were then predicted based on the five fit parameters. There was good agreement between model and experiment for test systems with different properties (different modulus mismatch, E'_f/E'_s, film hardness H, and different film time dependence, t_R/τ_Q).