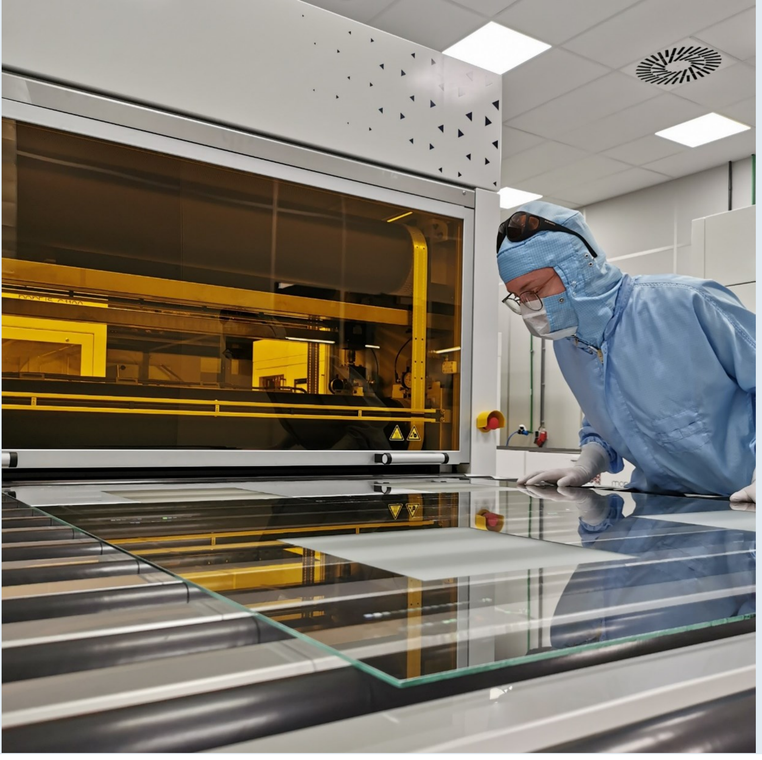

Elastohydrodynamics of Roll-to-Plate Nanoimprinting on Non-Flat Substrates

An elastohydrodynamic lubrication (EHL) study to reveal the influence of substrate waviness on the layer height in roll-to-plate nanoimprinting with tensioned webs.

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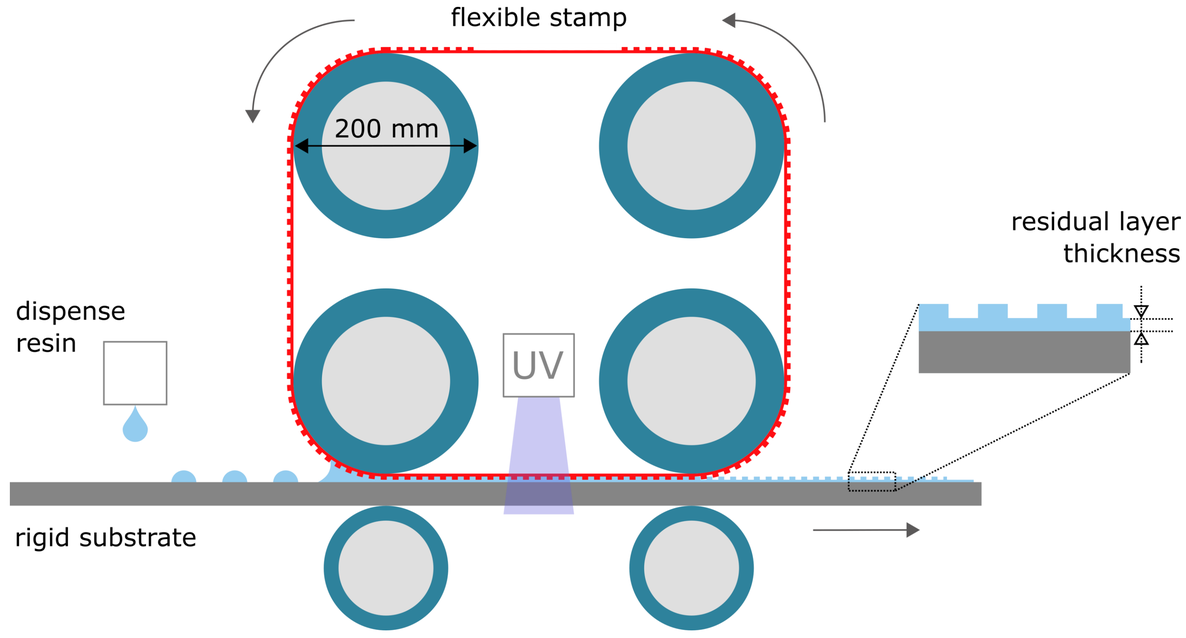
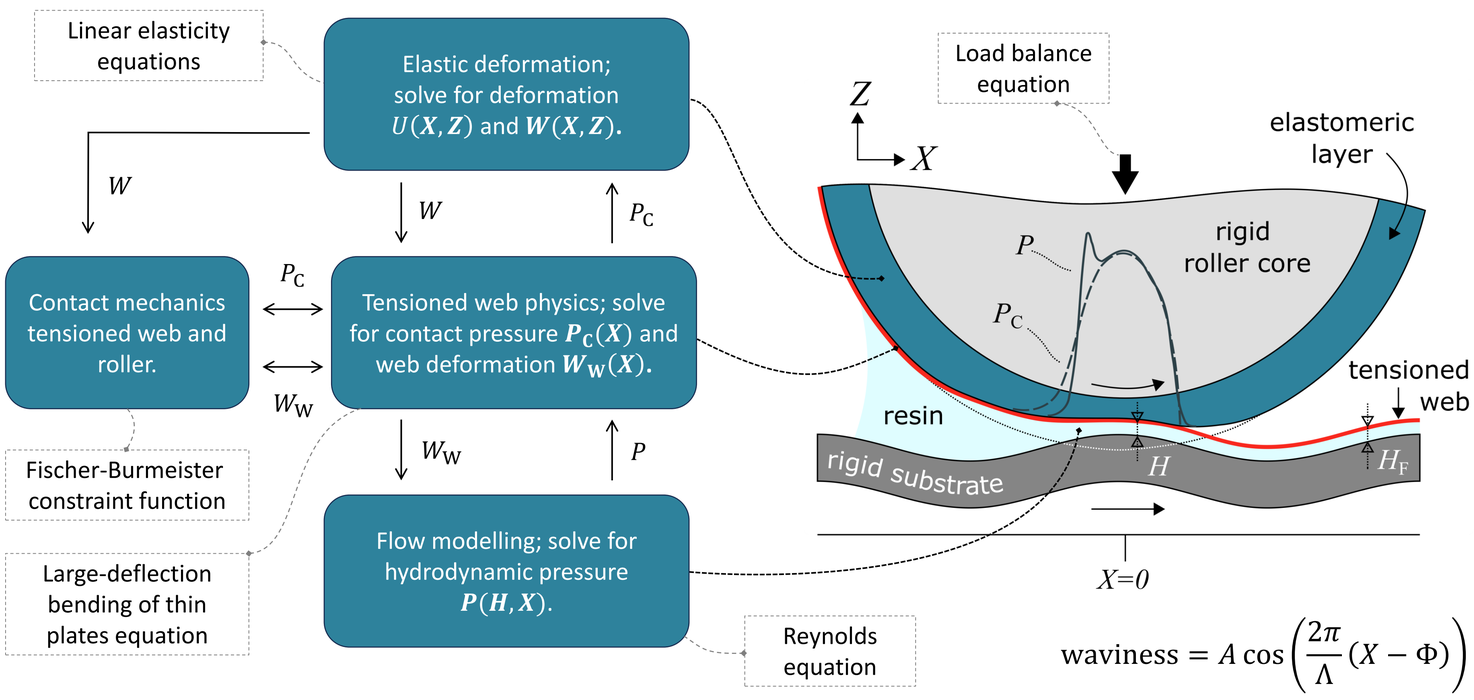
Introduction

- Roll-to-plate nanoimprinting is a manufacturing method to replicate micro- and nanotextures on large-area substrates [1].
- A small and uniform residual layer thickness is essential. It is governed by the interaction of the hydrodynamic forces in the UV-curable resin and the elastic forces of the flexible stamp and the elastomeric layer around the imprint roller.
- Substrates are typically non-flat and show a waviness which influences the applied layer height. A numerical model is used to further improve the predictability and uniformity of the final layer height.





$$\text{waviness} = A\cos\left(\frac{2\pi}{\Lambda}(X-\Phi)\right)$$

Methods

- The line contact model is based on the full-system FEM approach for EHL problems [2][3]. The relevant physics are coupled to each other.
- For numerical stability and faster convergence, all variables are scaled. The dimensionless equations are implemented via the Weak Form PDE interface (linear elasticity) and the General Form Boundary PDE interface (others).
- Quasi-static simulations are performed to compute the height and pressure profiles for varying substrate waviness.

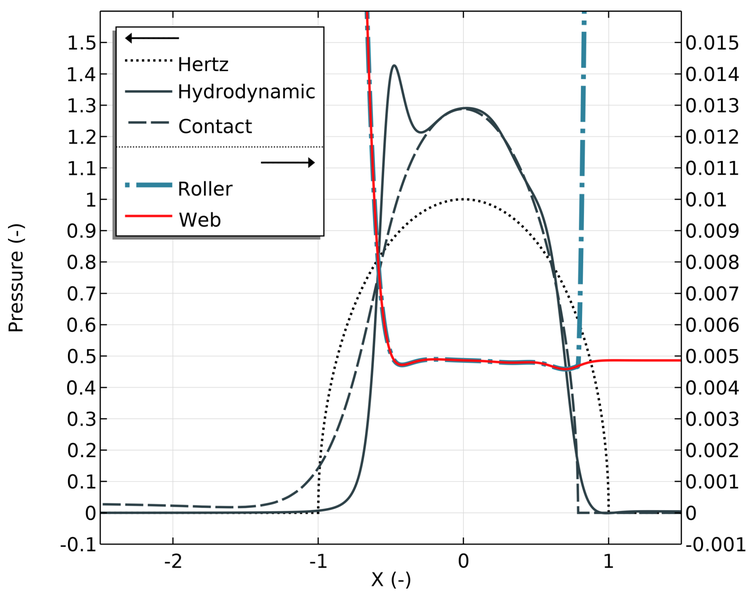


FIGURE 1. Pressure and film height profiles for $\Phi = 0$.

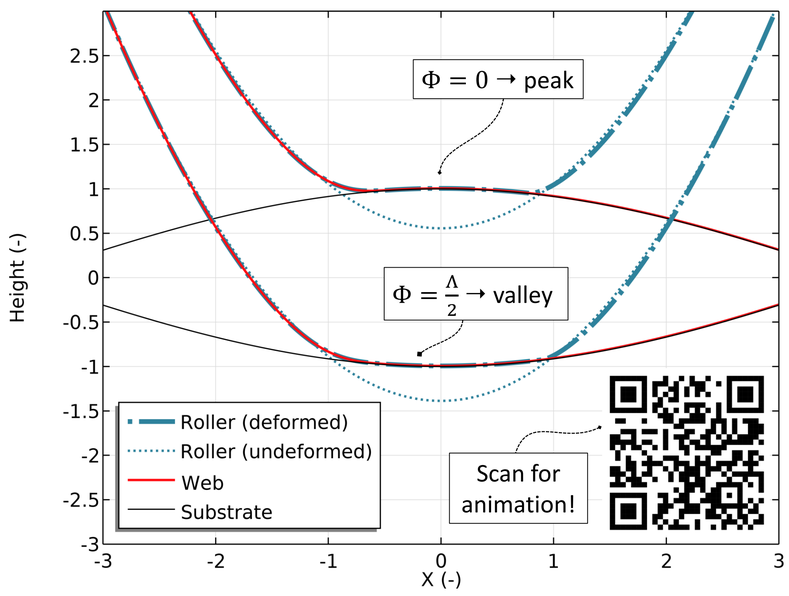


FIGURE 2. Roller and web surface for $\Phi = 0$ and $\Phi = \frac{\Lambda}{2}$.

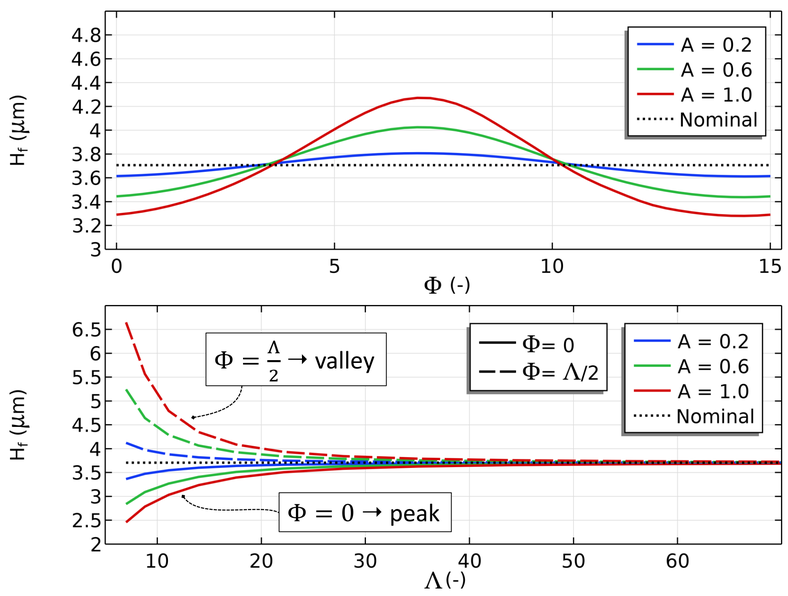


FIGURE 3. Final layer height for varying waviness parameters.

Results

- Typical results are shown in Figure 1-3. Figure 1 shows the pressure and film height profiles. The roller and web conform to the waviness of the substrate, as can be seen in Figure 2.
- Results for a varying phase shift and amplitude (top), and varying wavelength and amplitude (bottom) are shown in Figure 3. The influence on the layer height is most severe for a peak/valley below the roller, and for small wavelengths and large amplitudes.

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