Appendix I: Calculation of the extension rate of the filaments

The extension rate of the filaments is determined by the separation speed of the contact points on the roll and the substrate (the exact extension rate in each part of the filament is more complicated, as will be discussed later). The length of the filament after separation of the contact points can be obtained by a simple geometrical calculation. By taking the derivative of the length over time and dividing it by the filament length itself, the extension rate of the filament can be obtained, which is non-linear as a function of time:

$$\dot{\varepsilon} = \frac{v[(\theta - \sin\theta)(1-\cos\theta) + \sin\theta(h + R - R\cos\theta)]}{(h + R - R\cos\theta)^2 + (R\theta - R\sin\theta)^2} \tag{1}$$

with

$$\theta = \frac{vt}{R} \quad \text{when} \quad t > 0, \tag{2}$$

in which v is the speed of the substrate, R is the roll radius, t is the time, h is the thickness of the precursor layer and θ is the angle of rotation of the roll. The thickness of the precursor layer h is used as the initial length of the filament in this estimation. Note that because of surface tension, the ends of the filament form cones and are deformed less than the middle, so the entire filament goes through a non-uniform extension and only the total (or nominal) extension rate can be deducted from the above equation. The extension rate of a filament pulled out by a roll with a diameter of 1 cm and a substrate speed of 1 m/s is shown in Fig.1. This extension rate is typically on the order of a few hundreds per second.

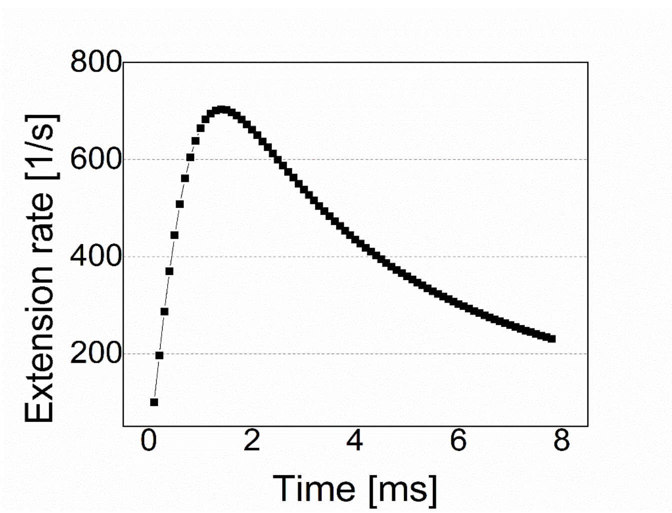

Figure 1 the nominal extension rate of the filaments pulled out by a 1 cm roll with the substrate moving at 1 m/s calculated from Eq.1 and 2, note that the calculation is based on the total length of the filament, and the non-uniformity in diameter along the filament is not taken into account. Hence the true strain rate is different from the calculation.