Supplementary File

Bowstring stretching mechanism

In a bowstring stretching experiment, the AFM probe is pressed against the substrate and moved towards the fibril at a constant velocity. Before being contacted by the tip the fibril appears as a dark line on the optical images (Fig. S1a). The point of first contact is determined optically (Fig. S1b). At first the fibril is being bent gently around the tip with an arc shape (Fig. S1c) and the length of the arc increases with tip displacement (Fig. S1d) until a triangular shape is formed (Fig. S1e). After that the fibril continues to stretch as a triangle and becomes optically bright all the way to the attachment points in the glue (Fig. S1f). The appearance of the fibril does not change during the relaxation phase (Fig. S1g) and returns to its original position within one video frame without losing the brightness it acquired (Fig. S1h). Note that the fibril segment next to the manipulated fibril remains dark and in focus during the whole process (Fig. S1h). We think that the fibril brightens during and after manipulation because it is not fully adhered to the substrate. This explains why a 45 nm tall aggregate on the side of the fibril (Fig. S2a, asterisk) was not moved by the fibril during manipulation (Fig. S2b, asterisk). A similar behavior was observed when the aggregates were taller and wider than the fibril (Fig. S3, asterisk, the aggregate is 150 nm tall, compared to the 100 nm tall fibril). In addition, the tip did not leave much of a dent or a mark where it contacted the fibril (Fig. S2-4). The position of the tip is easily found on the post manipulation AFM images (Fig. S2-4b) because it removed a thin layer of material on the surface along its path, the scrapped band as a typical width of 0.2 to 0.5 micrometers. This gives a rough estimate of the interaction length between the tip and the fibril.

Strain rate calculation

During a bowstring stretching experiment the fibril segments experience a non-linearly increasing strain and strain rate with time. Here we provide the strain rates formula for a fibril pulled asymmetrically by the tip. The path of the tip is along the *x*-axis, the tip moves at a velocity *v* in the positive direction. The origin of time and space is the point of contact between the fibril and the tip. The fibril makes an angle $\alpha>0$ with the *x*-axis and the tip will pull the fibril into two segments of length L_1 and L_2, below ($y<0$) and above ($y>0$) the tip respectively. Below are the strain rates for each segment as a function of time *t*:

$$\dot{\varepsilon}_1 = \frac{\frac{v^2 t}{L_1^2} - \frac{v}{L_1}cos(\alpha)}{\sqrt{1 + \left(\frac{vt}{L_1}\right)^2 - \frac{2vt}{L_1}cos(\alpha)}} \quad (1)$$

$$\dot{\varepsilon}_2 = \frac{\frac{v^2 t}{L_2^2} + \frac{v}{L_2}cos(\alpha)}{\sqrt{1 + \left(\frac{vt}{L_2}\right)^2 + \frac{2vt}{L_2}cos(\alpha)}} \quad (2)$$

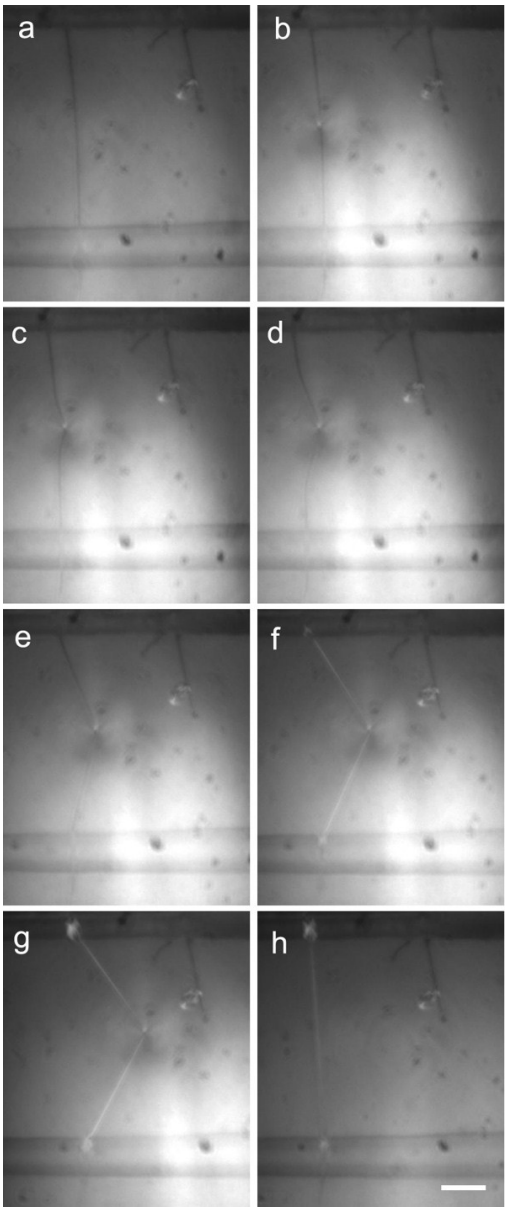

Figure S1: Video frame of a bowstring stretching experiment. The fibril was stretched to 17% strain and released after 150 s of relaxation. a) Fibril before the experiment starts. b) the AFM tip is just touching the side of the fibril. c) 2 seconds after first contact. d) 4 seconds after first contact. e) the fibril has reached a triangular shape 6.4 seconds after first contact. f) 12.4 seconds after first contact, notice the change in brightness all the way to the attachment points in the glue compared to a). g) after reaching maximum strain and relaxation time of 150 seconds, just before release. h) the frame after the fibril was released, it returned to its original position while remaining bright. Scale bar is 10 micrometers.

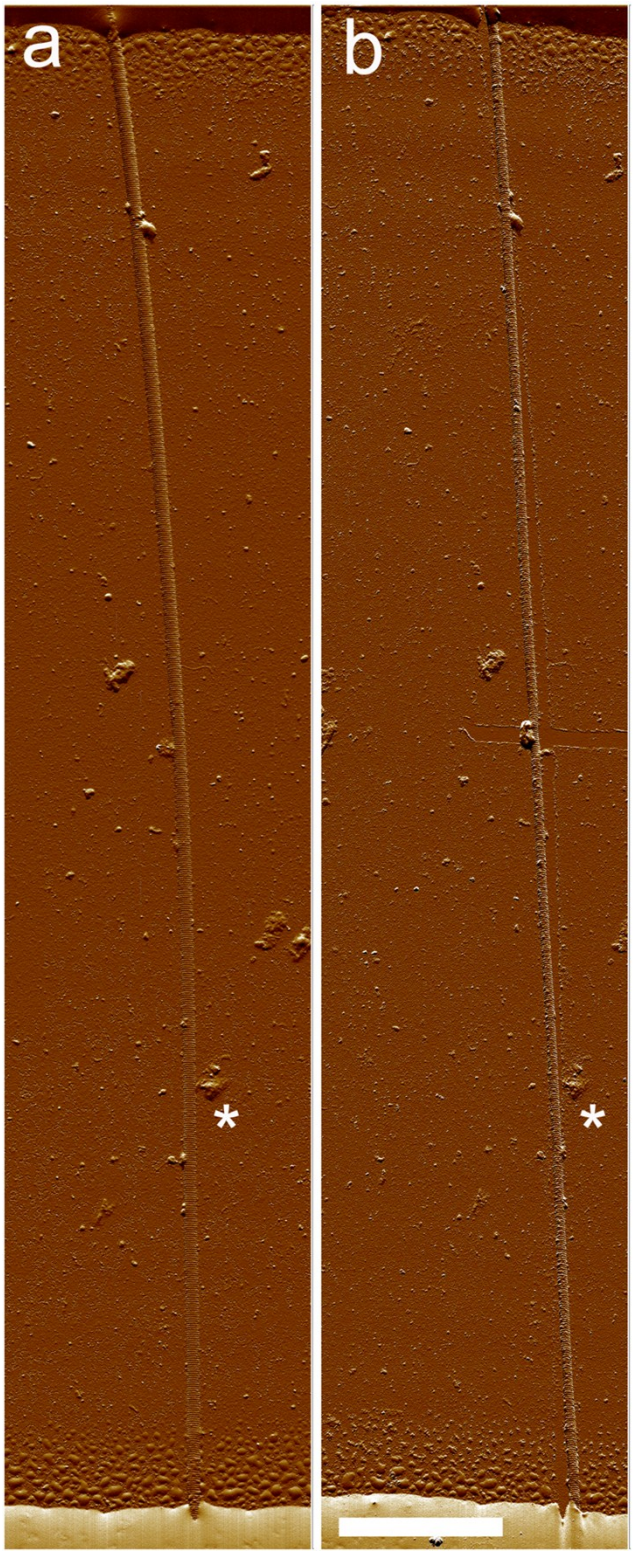

Figure S2: Peak force error AFM images of the fibril in Figure S1. a) before and b) after manipulation. The asterisks indicate a 45 nm tall aggregate that was on the fibril path and remained in place. The scale bar is 5 micrometers.

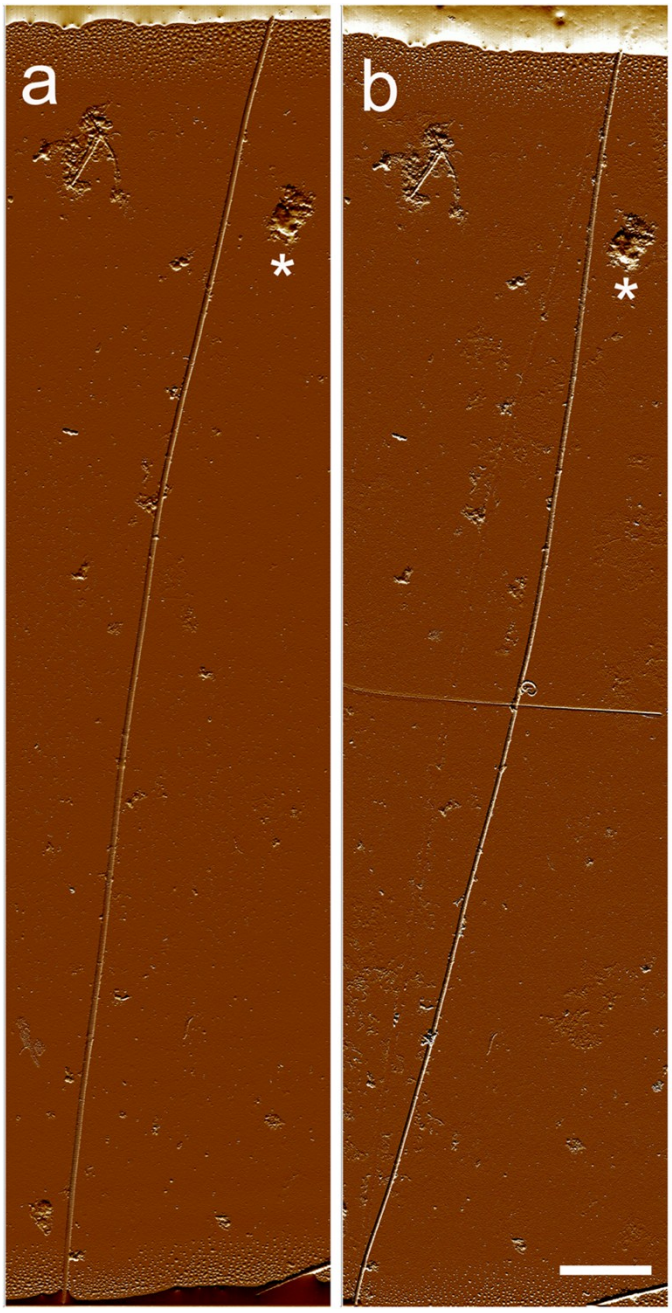

Figure S3: Peak force error AFM images of a fibril stretched asymmetrically to 18% and 4% and held for 150 s. a) before (see Movie S1for a high-resolution scroll through the image from the top) and b) after manipulation (see Movie S2 for a high-resolution scroll through the image from the top). The asterisks indicate a 150 nm tall aggregate that was on the fibril path and remained in place. The scale bar is 5 micrometers.

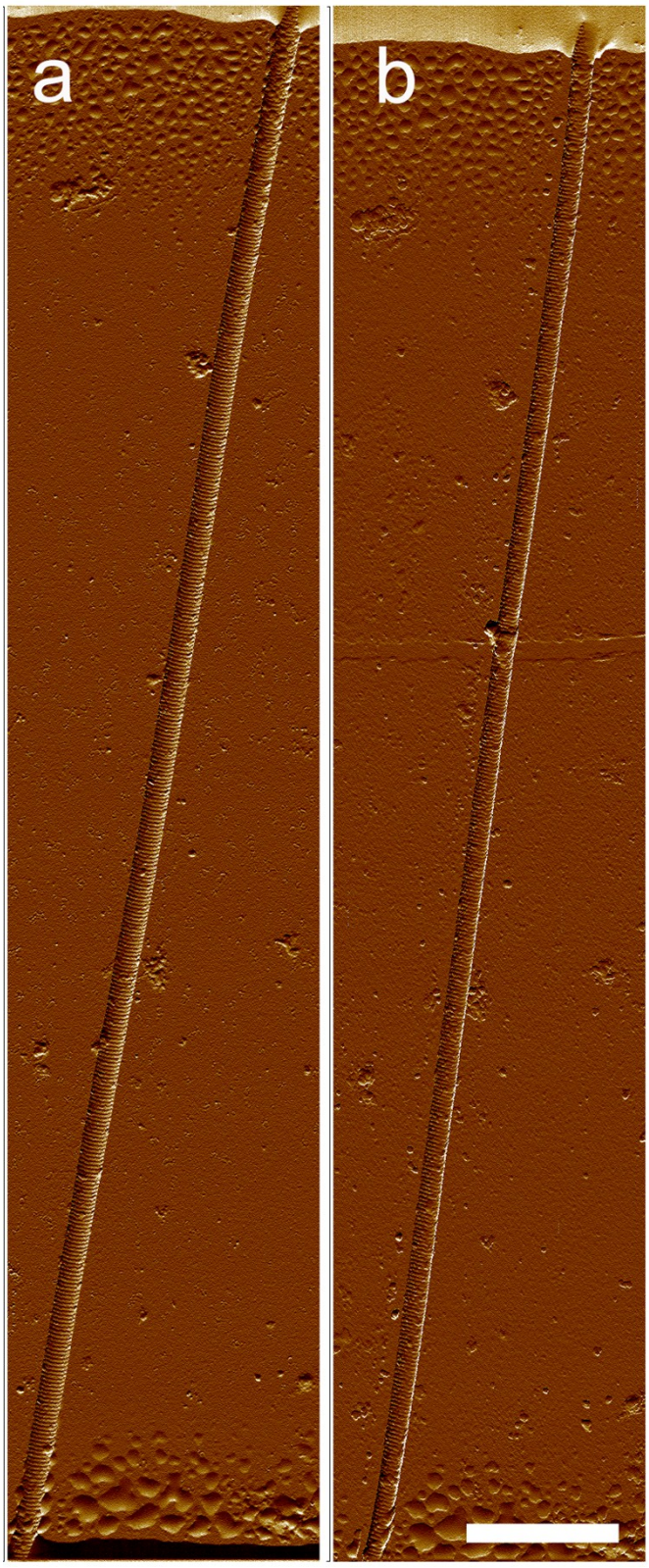

Figure S4: Peak force error AFM images of a fibril stretched asymmetrically to 18% and 12% and held for 1 s. a) before and b) after manipulation. The scale bar is 2.5 micrometers.