Adhesion force between rough surfaces

On rough surfaces the adhesion force is widely distributed (Götzinger et al. [34]). For example, adhesion force distributions of a $10\,\mu m$ polystyrene particle and silicon wafer coated with $110\,nm$ and $250\,nm$ SiO_2 nanoparticles are shown in Figure 1. The wafers are coated with dip-coating technique [35], so that the particles build a densely packed monolayer on the wafer surface. These adhesion force measurements are carried out with AFM (Nanoscope IIIa) equipped with NP20 (Veeco, California) cantilevers with spring constants of $0.245\,N/m$. The normal force is controlled in the range $750 \pm 250\,nN$. The measured adhesion forces are shown in Table 1 in comparison with the simulation results.

The simulation results are achieved with normal forces of $F_N = 845\,nN$ for a wafer with $110\,nm$ SiO_2 coating and $F_N = 677\,nN$ for wafer with $250\,nm$ SiO_2 coating, respectively. These values fall in the range which is applied in the measurements. The simulation gives a reasonable fit for the minimal values of the adhesion forces, which is approximately equal to the adhesion force between the particle and a single asperity. Deviations occur because the exact position of the approaching sphere relative to surface asperity cannot be determined exactly in the experiment. Our methodology reported in (Götzinger et al. [34]) did show that adhesion forces distributions between a rigid sphere and a rough surface can be reproduced.

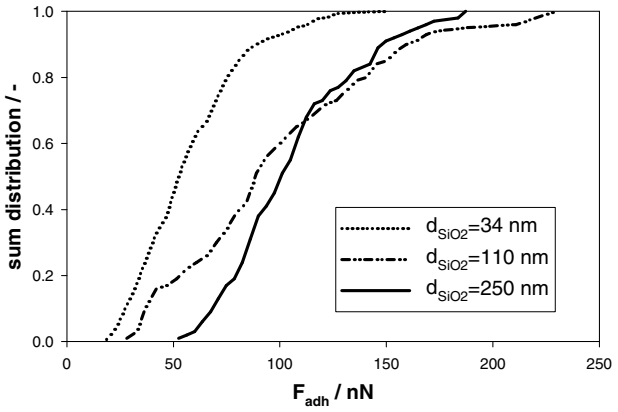

Figure 1 Adhesion force distribution between a polystyrene particle and silicon wafers coated with 34 nm, 100 nm and 250 nm SiO2 nano-particles.

Table 1 Adhesion forces measured with AFM in comparison with the predictions of simulation.

Asperity size on substrate	$F_{adh,FEM}$	$F_{adh,min}$	$F_{adh,50}$
$34\,nm$	$8\,nN$	$19\,nN$	$52\,nN$
$110\,nm$	$25\,nN$	$28\,nN$	$89\,nN$
$250\,nm$	$42\,nN$	$52\,nN$	$100\,nN$