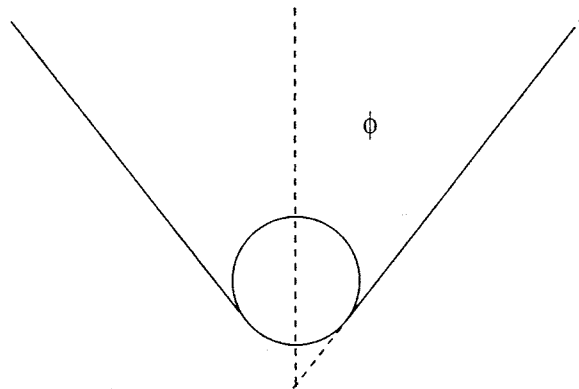


6.781
Submicron Structures Technology
Homework Set #9

33. Scan the attached article entitled "Scanning force microscopy in biology", C. Bustamante and D. Keller, *Physics Today*, Dec. 1995.

a) Comment on the resolution achievable with an AFM, particularly as discussed in Box 1.

b) For a tip with radius R , and angle of approach ϕ as shown in the diagram, sketch the image for a much narrower linear object sticking up out of a substrate (say a carbon nanotube) labeling the appropriate dimensions.



c) For this same tip, sketch the image when going over a sharp step in a substrate for various step heights (much less than R and much larger than R).

d) Now sketch the image that would result from going into a narrow trench (again, consider the cases where the trench is of various depths and widths relative to R).

e) Under what circumstances (feature, and tip dimensions) might a tip break or at least receive a large impact while scanning a step?

34. Read the attached article "Scanning interferometric Apertureless microscopy: optical imaging at 10 Angstrom Resolution", by Zenhausen, Martin, and Wickramasinghe, *Science* 269, 1083 (1995). In a few brief

words explain why the resolution obtained with this type of microscope exceeds the resolution discussed in Lecture 2. Comment on any change that has taken place in the past 10 years to alter the situation presented in the article.

35. Read the attached article "Nanotubes as nanoprobe in scanning probe microscopy" by Hongjie Dai, et.al. *Nature*, v. 184, p. 147 (1996). What are the claimed advantages of using nanotubes rather than the conventional AFM tips? Have nanotubes become commercially available as AFM tips over the intervening years?

References

Problem 33

Bustamante, C., and D. Keller. "Scanning Force Microscopy in Biology." *Physics Today* (December 1995): 32-38.

Problem 34

Zenhausern, F., Y. Martin, and H. K. Wickramasinghe. "Scanning Interferometric Apertureless Microscopy: Optical Imaging at 10 Angstrom Resolution." *Science* 269 (August 25, 1995): 1083-1085.

Problem 35

Dai, Hongjie, Jason H. Hafner, Andrew G. Rinzler, Daniel T. Colbert, and Richard E. Smalley. "Nanotubes as Nanoprobes in Scanning Probe Microscopy." *Nature* 384 (November 1996): 147-150.