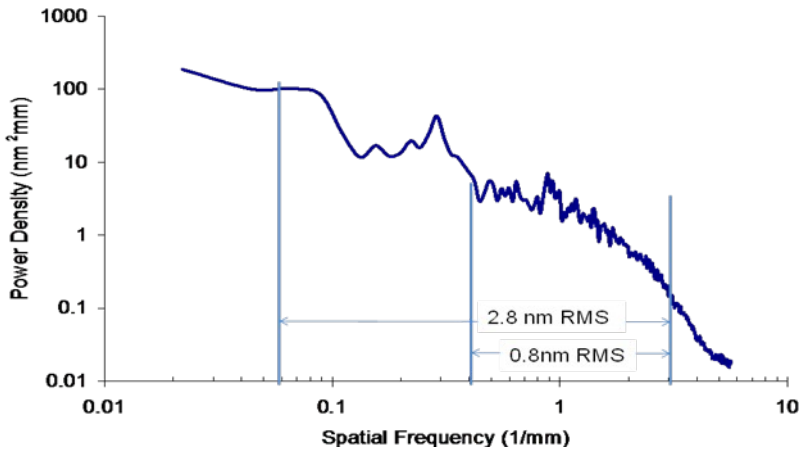
Surface roughness; the other forgotten specification

Second only to the scratch and dig specification, surface roughness is the most misused, misunderstood, and misinterpreted specification on an optical drawing. Unlike scratch and dig, however, which is frequently cited as the cause for rejection of an optics, surface roughness is the silent cost driver, forcing good companies to no-bid to a meaningless specification while others simply ignore the requirement, whether it was important or not. The solution to this problem, as with scratch and dig, is for both the customer and the supplier to understand what is meant by the various surface roughness specifications, and to develop a common language for interpreting them.

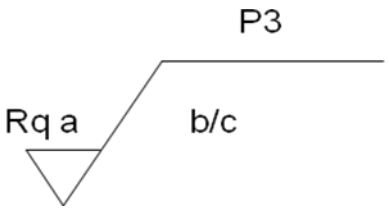
The first thing to be aware of is that there is no standard definition of surface roughness. That means that a specification of roughness without a reference to spatial bandwidth, such as "surface roughness < 5 Angstrom RMS", is completely meaningless (even aside from the fact that an Angstrom is not a scientific unit.)

The reason is that the surface texture of a polished surface is, for the most part, a statistical parameter which is a power function of the spatial periods considered in the evaluation. That means that the more trace length you measure, the higher the RMS. Moreover, studies on lapped metal parts have shown that the square of the RMS roughness increases as the scan length cubed. The RMS of polished glass parts see a lower dependence than metal, but still quite significant.



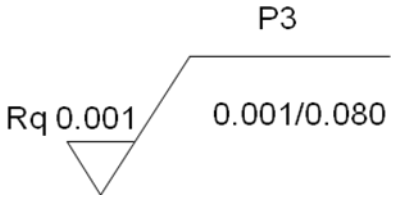
Power spectrum of a surface roughness trace. The RMS is just the square root of the area under the power spectrum. So the RMS increases with longer scale lengths, and decreases with shorter ones.

The best way to specify optical surface roughness is with ISO 10110-8, which draws upon the surface texture notation and calculations of the precision machining industry, documented in ISO 1302. While ISO 10110-8 is currently going through a major revision to bring it up to the latest version of the surface texture specifications in ISO, the existing notation is adequate for most applications. The symbology is:



Where a = the RMS roughness specification
b = the minimum sampling distance (usually 5 points on the trace)
c = the maximum sampling length (usually 1/3 the trace length)

For optics, a typical RMS roughness specification is:



Alternatively, one can simply add a spatial period range to the roughness note, such as "RMS roughness shall be less than 1nm for scale lengths from 1 micron to 80 microns." That, at least, will result in a meaningful specification.

Want to read more? Check out this presentation on mid-spatial frequencies by Rich Youngworth, Jessica DeGroote Nelson and Dave Aikens.