A wave-based polishing theory

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Abstract

The molecules of the reflecting surface are sources of Huygens' wavelets which make the reflected wavefront. These molecules can be nonplanar to the extent of a fraction of the wavelength while yet there exists practically reflected plane wavefront.

1 The theory

At first let's assume that a beam of light consists of some very thin rods of light. When a collimated beam of light descends on a polished surface within a determined angle, it will be reflected from the surface within an equal angle. If the descended surface is rough instead of being glossy, different parts or in fact different rods of the beam will be reflected in different directions depending on the orientation of the facets of roughness on which the rods of light descend. So, the surface appears matt instead of being polished.

To produce a polished plane surface we should give an oscillating and freely rotating movement to a plane tool on the rotating work surface while there is a powder of equisized abrasive grains (mixed in water) between the tool surface and work surface. These grains due to their movement and pressure on the glass surface break the glass surface in some dimensions comparable with their sizes, and so a plane surface will be obtained that have some unevenness the bigness of which are in the order of the size of the grains; if the size of each working grain is about ten micron the obtained surface will be matt and the process is named smoothing, and if, after smoothing, the size of each working grain is about one micron the obtained surface will be polished and the process is named polishing. In this manner we see that even a polished surface has a rough surface the size of unevenness of which is in the order of the size of polishing abrasive grains. And it is obvious that the shape of unevenness of the surface after polishing should be similar to its shape of unevenness after smoothing.

Now if the theory presented at first for the reflection (based on considering a beam of light as a collection of rods of light) is true, why should we see our surface after performing the polishing process as a reflecting (polished) surface while its similar surface after smoothing is matt? (We know that according to this theory what causes a surface to be glossy is not the smallness of the roughness of the surface but is nonexistence of the roughness ie nonexistence of angles crossing the continuation of the surface.) Existence of such a contradiction between the mentioned theory and what in practice shows a surface worked by polishing powder glossy has caused creation of justifying theories of athermic surface flow (Beilby et al) [1, 2, 3] and formation of a silica-gel surface (SiOH) by hydrolysis (Grebenshchikov et al) [4] in one of which it is said that the solid surface flows and fill the unevennesses of the surface to produce a continuous smooth glossy surface and in the other one it is said that this work is done by the produced silica gel. These theories and other similar theories in this respect have not been proven clearly and are rather as proposal.

To solve the problem let's define correctly a glossy surface. To do this, we should realize correctly the physics of reflection since after that we can define a glossy surface as a reflecting surface.

Pointing to rods of light propagating in straight lines and acting like some balls which after hitting a wall will rebound (or be reflected) does not certainly become a physicist when trying to define reflection, since as a rule he/she is aware of the wavy nature of light. Thus, let consider a plane wavefront (instead of the beam conception) reaching the molecules (of a surface to be glossy) set in a geometrical plane surface within a determined angle. Exposed molecules will be sources for radiating spherical (Huygens') wavelets [5] envelope of which is the same wavefront of the reflected wave. It is clear that since the molecules are coplanar the angle of reflection is equal to the angle of incidence, and in more accurate words in other angles of reflection there is no plane envelope of visible propagating wavelets.

In this manner the condition of reflection is that the molecules of the reflecting surface be coplanar. What is the tolerance of this coplanarity? It is clear that if these molecules are not coplanar only to a very small extent we can have the same reflected plane wavefront, although not with the same ideal qualification, within the same reflection angle. This tolerance is a small fraction of the incident wavelength. So, the molecules existent about an ideal plane surface within the vertical distances smaller than a fraction of the wavelength can reflect the plane wavefront incident on themselves as acceptable plane reflected wavefront within an angle equal to the angle of incidence. These molecules can be the molecules of all the facets of the roughness of a (polished) plane surface provided that the depth of the pits is smaller than the same fraction of the wavelength. Therefore, it is not surprising that while with an electron microscope polishing tracks left behind the abrasive grains of the polishing powder or in other words roughnesses of the polished surface (due to the polishing powder) are visible, the surface appears polished and glossy and scrachless with naked eyes or with the optical microscope. These grooves and unevennesses are not filled with anything, but they are not seen.

As Rayleigh Roughness criterion states if the depth of each roughness relative to the continuation of the reflecting surface is h and the acute angle between the incident plane wavefront and the reflecting surface is T, the depth of roughness relative to the (continuation of) the incident wavefront will be h.cosT, and that's why for grazing incident beams (in which T approaches 90 degrees) the (reflecting) surface is more reflective. Also a roughness is more reflective for a long wavelength than for a short one because the depth of roughness is a fraction of the wavelength smaller in the first case than in the second one.

As we see corpuscular theory of light cannot really justify existence of a polished surface, while wave theory of light can do this act quite well.

References

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