
Letter to the Editor

Dissertation on the polishing of spherical objects by S. Hambücker – A critical review

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In his dissertation [1], the topic of which is the polishing of spherical optics, Hambücker stresses the existing theories for the polishing of glass, including my tribochemical theory that is based on the presence of lattice defects in oxide polishing agents. Hambücker summarizes the results of his investigations as they apply to my theory on pages 72 and 73 of his dissertation in the section „Wechselwirkung Korn und Glaswerkstoff“ (The Interaction Between Polishing Grains and Glass). He concludes that his results show that my theory has no validity for the polishing process. Further, on page 126 of his dissertation, Hambücker once again emphasizes that the methods he used in his experimental work could not confirm my hypothesis that material removal is initiated through a reaction between glass and polishing grains.

The results of Hambücker's experiments are correct, as far as they go, but the measurements were done on the wrong thing, namely, on the loose grains suspended in the polishing liquid. These loose grains do not participate in the polishing process; only the grains that are embedded in polishing pitch or other material on the polishing plate participate in glass removal. Loose particles in the suspension liquid are not participants in glass removal. They only serve to increase the amount of polishing media in the polishing plates, if they are present there. Hambücker's procedure was to compare unused grains of polishing media with loose grains taken from polishing liquids from the central delivery tanks of polishing lines. These loose grains could have seen hundreds of hours of polishing exposure. However, since loose grains in the polishing suspension do not participate in glass removal, one should not detect any structural changes in these grains.

The problem is that Hambücker overlooked a substantial number of my publications on the polishing of glass and the properties of polishing agents for tribochemical polishing. He cites five of my twenty articles on these topics. It is especially important that he does not cite [2], in which it is expressly emphasized that a polishing agent only has an effect on a glass surface when there is a good “polishing crust” on the polishing plate; i.e., when the grains of the polishing agent are firmly embedded in the polishing pitch. This fact is shown even more clearly in figure 1 in [3]. Hambücker cites none of my articles published after 1990, i.e., [3 to 6]. Since Hambücker does not provide a correct view of my tribochemical theory of glass polishing, a condensed version is presented here.

By definition, tribochemistry [5] is a branch of chemistry that is concerned with the chemical and physical-chemical changes in solids that occur as the result of the effect of

mechanical energy. One of the principal effects of mechanical energy is tribology, which is friction and wear. In the case of polishing of glass, one is dealing with friction between the polishing grains that are embedded in the carrier material and the glass surface. In the polishing process, wear of the polishing grains occurs in a surface layer that is just one or several nm thick. According to Rebertisch and Dinkelacker [7], who measured 3000 to 4000 polishing grains in an electron microscope, the decrease in size of these grains after five hours of simulated polishing was about 22 nm. This demonstrates that polishing grains only experience abraded brink in a very thin surface layer; i.e., the grains do not experience an intensive milling, as described by Hambücker. The lattice defects of the polishing grains are exposed by this abraded brink, and these defects bond with molecules on the glass surface. Thus, with further motion of the polishing plate, molecular components of glass wear come in contact with the water-based suspension liquid, the adsorbed glass particles are hydrolyzed, and they go into solution as dissolved silicates. The surfaces of the polishing grains are exposed in this way for the next surface wear, so that the glass components are continuously worn away at the molecular level.

Another point to mention in connection with figure 2.46 in Hambücker's dissertation is that lattice defects in the polishing grains that are caused by vacancies are X-ray amorphous [8 and 9], and, therefore, cannot be detected by X-rays. This is a second reason why the powder-diffraction results shown in figure 2.46 give no indication of lattice defects.

In summary, Hambücker's arguments for the invalidity of the tribochemical polishing theory are based on experiments that are themselves invalid, since a) they cannot detect lattice defects, and b) lattice defects are not expected in the grains that were in suspension.

In my work, I have shown that lattice defects are not only the most important characteristics of an effective polishing agent, but their presence is the only characteristic that is responsible for glass removal during polishing. This was proven in two examples. One was a comparison between a γ -Fe₂O₃ and an α -Fe₂O₃. The γ -Fe₂O₃ was oxidized in the solid state to γ -FeO-OH through a bivalent iron hydroxide, Fe(OH)₂, with a change in valence. This had very strong lattice defects and a good polishing action [10]. The α -Fe₂O₃ polishing agent was transformed through a trivalent iron hydroxide, Fe(OH)₃, without a valence change, in the solid state, into α -FeO(OH) and further into α -Fe₂O₃. This had no lattice defects and exhibited no polishing action [11]. The second example is the Zeiss red polishing agent 19. This is created in an explosive reaction that results in a mixture of bivalent iron sulfate, potassium chlorate, and wheat starch.

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It has a very good polishing action due primarily to a basic iron-oxide sulfate with the chemical formula of jarosite, $K(Fe^{+3}O)_3(SO_4)_2$ [4 and 5]. On the other hand, a material that is synthetically produced in a water-based solution from trivalent iron sulfate, but without a valence change of the iron ions, has no lattice defects and, therefore, no polishing action [11].

Translation by James Varner

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