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SURFACE SCIENCE IN FINE CERAMICS

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In the last twenty years there has been an explosion of development in ceramics. Man's oldest materials have become "fine" ceramics. The revolution started when ceramic engineers realized the role of precursor powders in the properties of the final ceramics. Ceramics are unique man-made materials for the final structure has the same composition as the starting powder. Metals are won from ores, smelted, cast, rolled and shaped—the product very different from the original ore. The same is true for polymer-materials that form by reaction of chemicals totally different from the final product.

So the powders control but, what controls the powders? Their surface! Surface chemistry and physics facilitate manipulation of ceramic powder properties and this in turn controls the structural and functional properties obtained. Lets consider an example—electrophoretic deposition. This procedure is enjoying increased application for the shaping of complicated functional ceramics. The secret of the process is manipulation of the surface charge on powder particles in a suspension such that they move in an applied field and flocculate at the attracting electrode. A deal of surface science is involved, especially in the case of nonaqueous suspending-media. The latter have low dielectric constant so inducing particle surface charge requires polar chain-molecule adsorption and subsequent ionic trapping therein. The particles now phorese to the oppositely charged electrode and must be induced to deposit. Considering the suspension has purposely been stabilized (deflocculated) it must now be rendered unstable (flocculated). This is accomplished by discharging the particles and having them bond via interlocking of the adsorbed chains—sounds complex?—it is! and illustrates the major contribution made to ceramic development by surface science.

Other surface considerations in the synthesis and application of fine ceramics are multitude. Sintering is a function of powder surface area; anisotropic property manipulation via texturing depends on powder particle morphology (aspect ratio); fracture toughness depends on surface area production on fracture.

I often tell students of Ceramic Engineering to be concerned with the term in the free energy equation largely ignored by other material engineers, ie.

$$dG = dH - Tds + \Sigma \mu_i dn_i + \gamma dA$$

$$\frac{dG}{dA_{T.P.n_i}} = \gamma, \qquad \text{the surface energy !}$$

It is appropriate the Surface Science Society of Japan devote an issue of the Journal to this most important aspect of ceramic science.

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