"Introduction to Grains, Phases, and Interfaces—an Interpretation of Microstructure," *Trans. AIME,* 1948, vol. 175, pp. 15–51, by C.S. Smith

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SMITH'S seminal 1948 paper, "Grains, Phases, and Interfaces—an Interpretation of Microstructure," has influenced scientists for six decades and continues to be a base upon which modern materials research is built. Because the current fashion is to measure a paper's impact on the scientific community through its citations, I'll begin by noting that as of January 2010, this paper has been cited 831 times since it was published (according to the ISI web of science). What is remarkable about these citations is that more than 100 of them occurred in the 4-year period between the start of 2006 and the end of 2009. This demonstrates that the paper has maintained its relevance to modern materials research 60 years after it was published. I do not doubt that in the future students of materials science will continue to read, and be inspired, by this work.

The basic idea put forth by Smith is that the geometry of a microstructure contains an "imprint" of the interfacial energies of the constituent solids and liquids. As a result, interfacial properties can be used to predict the microstructures that will be formed during materials processing and, conversely, relative interfacial properties can be determined from the interpretation of microstructures. The analysis is based upon the simple vector balance of interfacial energies at the junctions between misoriented crystals, different solid phases, solids and liquids, or solids and gasses. Within this framework, relative energies can be determined from the dihedral angles between interfaces, under the assumption of local equilibrium usually obtained at high temperature during microstructure genesis. The entire analysis is illustrated by 30 beautiful optical micrographs.

One significant idea advanced by Smith in this paper is that grain boundary energies are anisotropic. While virtually nothing was known about grain boundary energies at the time, Smith argued for anisotropy on the basis dihedral angle measurements. Furthermore, from the observation that the junctions between twin boundaries and random grain boundaries, he realized that the former must have very low energies and that the latter must have an energy that depends on the boundary plane orientation. These conclusions, of course, have been proven to be accurate.

It is also noteworthy that while micrographs from plane sections are two-dimensional, real microstructures are three-dimensional. In the past, researchers frequently (and perhaps conveniently) overlooked this point. However, throughout the paper, Smith relates the two-dimensional information in his micrographs to plausible three-dimensional arrangements. In fact, after this paper, Smith pursued the first studies of three-dimensional grain shape using grain separation techniques and stereoscopic microradiography. This seems especially relevant today, as new tools such as the dual beam focused ion beam scanning electron microscope and high energy X-ray tomography make it possible for the first time to visualize the three-dimensional internal microstructures of materials.

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