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Stereological Analysis of Polycrystalline Microstructure

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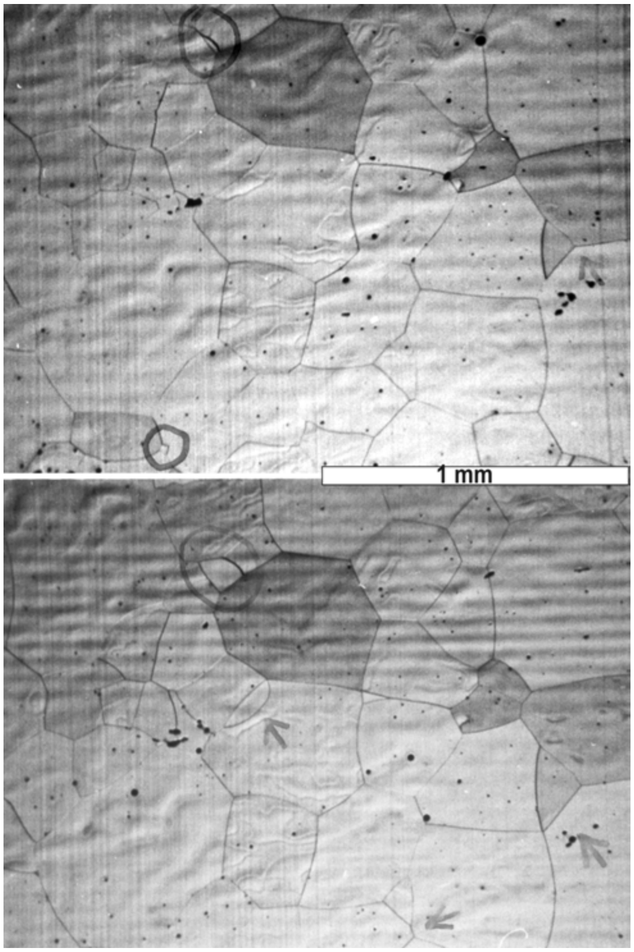
Stereological analysis of polycrystalline microstructure can be carried out using the physical disector [1], wherein closely spaced serial sections are analyzed for the appearance of new grains, faces, and triple junctions. A number of results of serial section analyses have been reported for the topological properties of polycrystals [2,3,4]. The topological properties include the number of grains, facets, triple junctions, and quadruple points present in the "statistical honeycomb" [5]. These topological properties also provide estimates of the average grain and facet shape, which are related by the famous Coxeter equation [5], $\mathbf{F = 12 / (6 - p)}$ .... **(1)**
where **F** is the average number of faces per grain, and **p** is the average number of edges per facet. Coxeter also demonstrated that **p** should be 5.104, and therefore **F** should be 13.40 for cell structures with facet angles at the vertices of $\cos^{-1}(-1/3)$ (i.e.109.5^{o}), which is required for a balance of surface tension forces within the boundary network.

Data from a series of serial sections through an Al-1%Mg alloy structure are presented in Fig. 1, which shows optical micrographs of a pair of adjacent serial sections with the appearance of two new grains circled for identification. The cumulative counts of the number of features are shown as Fig. 2 for the 72 sections analyzed. The rules used for counting features intersecting the field boundaries were that those features intersecting the sides of the sectioned volume were counted as **½**, and those intersecting the corners as **¼** . The number of features counted is thus called a cumulative effective number. The slope of the linear least squares fit of the straight line provides an estimate of the number per unit volume (N_V). The coefficient of variation can be obtained from linear least squares fit of the data, although these estimates are not reported in this paper. Table I gives a listing of the estimates of the number of features per unit volume, and the average shapes obtained from these data.

Standard stereological measurements on 2-d sections can also provide estimates of the number of grains per unit volume, if a model for the 3-d microstructure of the polycrystalline aggregate is used. One of the classic models is the generalized Johnson-Mehl model described by Miles [6], which gives an average shape of **F** = 13.3. This model allows the estimated number of grains ($\mathbf{N_V}$) to be calculated from the average number of sections per unit area ($\mathbf{N_A}$) as, $\mathbf{N_A} = 1.258\ (\mathbf{N_V})^{2/3}$ .....
(2)

References
[1] D.C. Sterio, *J. Microsc.* **134** (1984) 127.
[2] J.H. Steele Jr., Stereology, Elias (Ed.), Springer Verlag, N.Y. (1967) 74.
[3] R.T. DeHoff and G. Liu, *Met. Trans. A* **16** (1985) 2007.
[4] F.N. Rhines, et al., *Met. Trans.* **5** (1974) 413.

[5] H.S.M. Coxeter, *Ill. J. Math.* **2** (1958) 746.
[6] R.E. Miles, *Suppl. Adv. Appl. Prob.* (1972) 243.



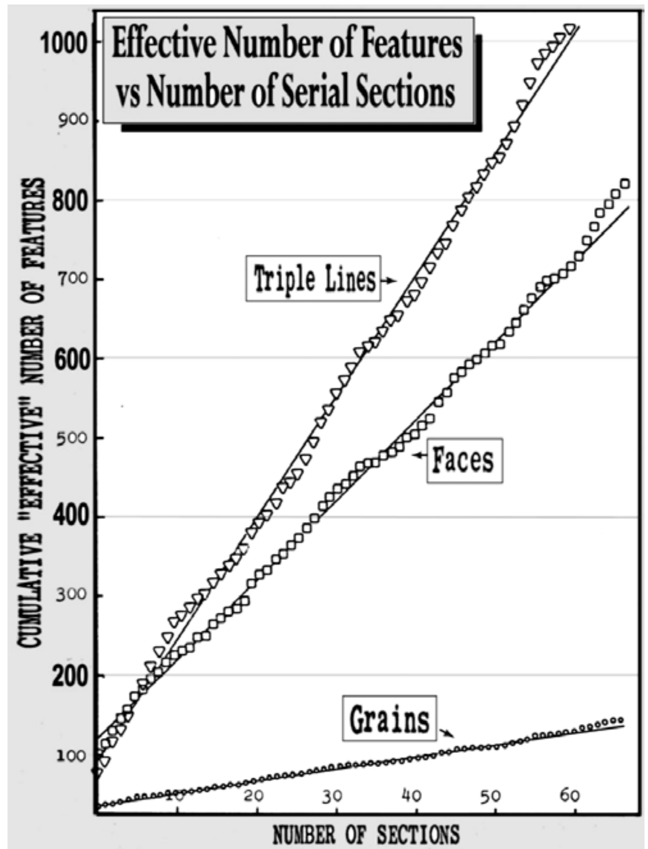


Fig. 1 Optical micrographs of a pair of serial sections.

Fig. 2 Plot of cumulative number of features.

Table 1 Results from 2-d measurements and serial section analysis.

Grains per Unit Volume	49.5 mm^{-3}
Facets per Unit Volume	344 mm^{-3}
Triple Junctions per Unit Volume	524 mm^{-3}
F = Average Grain Shape	13.9 faces/grain
$\mathbf{S_V}$ from 2-d measurement	8.25 mm^2/mm^3
$\mathbf{N_A}$ from 2-d measurement	18.3 mm^{-2}

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