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The structure of Guinier–Preston zones in aluminium–copper alloys.

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In a recent paper Toman (1957) has calculated the distribution of copper atoms and the lattice distortion in Guinier–Preston zones. His results, however, may not correspond to the real conditions in this alloy. The present author's idea of this structure is the following (Gerold, 1954): The copper atoms of the supersaturated crystal cluster in lattice layers parallel (001). Each zone contains only one layer of copper atoms, which distorts elastically the surrounding lattice. The rth layer ($r = 0$ meaning the copper layer) is displaced by ε_r in the direction of the copper plane. In addition, Toman has found a considerable concentration of copper atoms also in the layers parallel to the plane $r = 0$. The atomic concentration m_r of copper atoms in the rth layer is listed in Table 1, together with the displacement ε_r according to Toman and the present author.

Table 1. *Distribution m_r of copper atoms and layer displacements ε_r after calculations of Toman* (1957) *and Gerold* (1954)

	Toman's model		Gerold's model	
r	m_r (%)	ε_r (Å)	m_r (%)	ε_r (Å)
0	100	0	100	0
1	50	$7{\cdot}88\times10^{-2}$	0	$20{\cdot}2\times10^{-2}$
2	39	3·11	0	18·8
3	30	0·69	0	17·4
4	23	0·06	0	15·9
5	17	0		14·5
6	13	0		13·1
7	9			11·7
8	6			10·3
9	4			8·9
10	2			7·5
11				6·1
12				4·6
13				3·2
14				1·8
15				0·4

The model of Gerold is based on the following assumptions: $m_0 = 1$, $m_r = 0$ for all $r \neq 0$, $\varepsilon_1 = 0{\cdot}2$ Å. All the other values ε_r are chosen more or less arbitrarily so that the calculated intensity distribution of the relrod (00l) corresponds to the observed scattering in the region $1 < l < 3$. This model is in agreement with the calculated strain distribution in a deformed metal. Toman's results are calculated directly from the observed intensity distribution along (00l) in the range $0 < l < 5$, without any assumption. They should give more accurate values than those of the present author. Simple arguments show, however, that Toman's model does not agree with the strain distribution. The arrangement of copper atoms found by him will produce stresses in the crystal of such a magnitude that the coherence of the deformed levels with the adjoining matrix is not maintained.

The failure of Toman's results does not arise from the mathematical procedure but rather from the observed intensity distribution. Besides the very strong maxima on the relrod (00l) near (002) and (004), Toman finds also a strong increase of intensity near (000), which is in the region of small-angle scattering (Toman, 1957, Table 4). In this region the intensity depends only on the density distribution in the crystal, i.e. only on the arrangement of copper atoms in the zones. A difference in the intensity curves near (000) corresponds to a difference in the m_r values. A streak along (00l) essentially without increase of intensity at small angles means a two-dimensional distribution of copper atoms ($m_0 = 1$, $m_r = 0$). The additional small-angle maximum of Toman indicates that copper atoms are distributed in three-dimensions ($m_r \neq 0$).

The small-angle maximum does not seem to be real; no one has observed it before (Guinier, 1949; Gerold, 1954). Theoretical arguments show that the maximum should be accompanied by a similar maximum, e.g. on the streak along (11l) at the point (110). It is certain that such a maximum does not exist. All the authors have found a monotonous streak in this region (Guinier, 1942; Gerold, 1954). The high m_r values in the paper of Toman may therefore be caused by an incorrect intensity curve in the small-angle range.

In the present author's model the intensity maxima near the matrix relpoints stem from displacements ε_r which are large. In the Toman model they are produced to a large extent by the high m_r values. He finds, therefore, only small displacements ε_r. If a correct scattering curve without small-angle maximum is used the mathematical method of Toman should give a distribution of m_r and ε_r similar to that of the author.

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Notes and News

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