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# Semi-quantitative evaluation of texture components and anisotropy of the yield strength in 2524 T3 alloy sheets

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ABSTRACT

Decreasing the anisotropy of 2524 alloys is a key factor for their use in applications such as high-performance inertial components or space robots. Studying the interaction between sheet textures and anisotropy is a key factor to overcome this problem. In this study, the semi-quantitative approach to estimate the relation between texture and in-plane anisotropy (IPA) of yield strength has been developed. The intensity ratio between Cube and Brass texture components ($F_{CGB}$) was used as an effective variable for this purpose. This approach has been tested in 2524 T3 aluminum alloy sheets, which were investigated using X-Ray diffraction, scanning electron microscopy, optical microscopy and tensile tests. The results show that $F_{CGB}$ decreased with an increase in cold reduction. The 2524 T3 sheet, dominated by Cube texture grains, possesses the lowest in-plane anisotropy for the yield strength of all texture components investigated. The alloy sheet dominated by Brass texture exhibits the highest anisotropy, while the Goss texture-led sheets fall in between them. These results agree with the trends seen in the factor $F_{CGB}$, suggesting that is suited to evaluate the anisotropy of yield strength in 2524 T3 alloy sheets semi-quantitatively.



## 1. Introduction

2524 Al-Cu-Mg alloy are widely used to manufacture aircraft skin sheets, owing to the high damage tolerance (HDT), moderate strength, and outstanding workability [1–3]. However, other applications, such as high-performance inertial components or robot arms of planetary landers, have been limited by the anisotropy of the mechanical properties.

In general, the anisotropy of the mechanical properties of an alloy matrix is related to the preferred orientation of the grains, the so-called texture components, owing to the different activated slip systems under an external load [4,5]. In the case of alloy sheets, the in-plane anisotropy (IPA) of the yield strength ($\sigma_s$) is one of the most significant approaches to evaluate the anisotropy of the mechanical properties. The effects of single texture components on the IPA of an aluminum alloy have been reported in several studies. Jata [6] claims that the IPA index of the yield strength increased with the volume fraction of Brass texture ($\{011\}<112>$) in Al-Li alloy sheets. Rioja [7,8] have found a similar conclusion, and tried to fabricate isotropic Al-Li alloys and products for space and aerospace applications by reducing the intensity of crystallographic texture components.

The coefficient of anisotropy in the plastic strain ratio (r) on the normal plane, namely $\Delta r$, is another index to evaluate the anisotropy of the mechanical properties in alloy sheets. The influence of texture on the value of r has also been widely studied. Han et al. [9] found that the anisotropy in the r-value decreased with increasing amount of random texture components. Choi [10] claimed that the enhancement of ND-Rotated Cube texture components contributes to a decrease of the planar anisotropy ($\Delta r$) when the reduction ratio increased in Al-Mg alloy sheets.

However, research seems to be scarce and scattered with respect to the relationship between texture and the anisotropy of mechanical properties, caused by the lack of a parameter to evaluate the texture components effectively. The reason may be that in most cases alloys have multiple texture components, making the comparative analysis based on single texture intensity difficult. The texture intensity f(g) is only suitable for a qualitative discussion. In addition, it is difficult to obtain reasonable results

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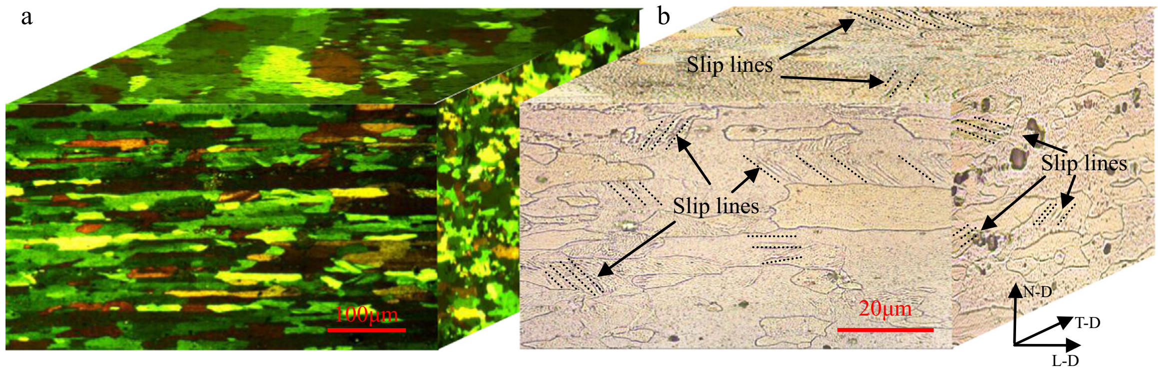


**Fig. 1.** Optical microstructure of (a) a 2524 T3 sheet and (b) the region near tensile fracture.

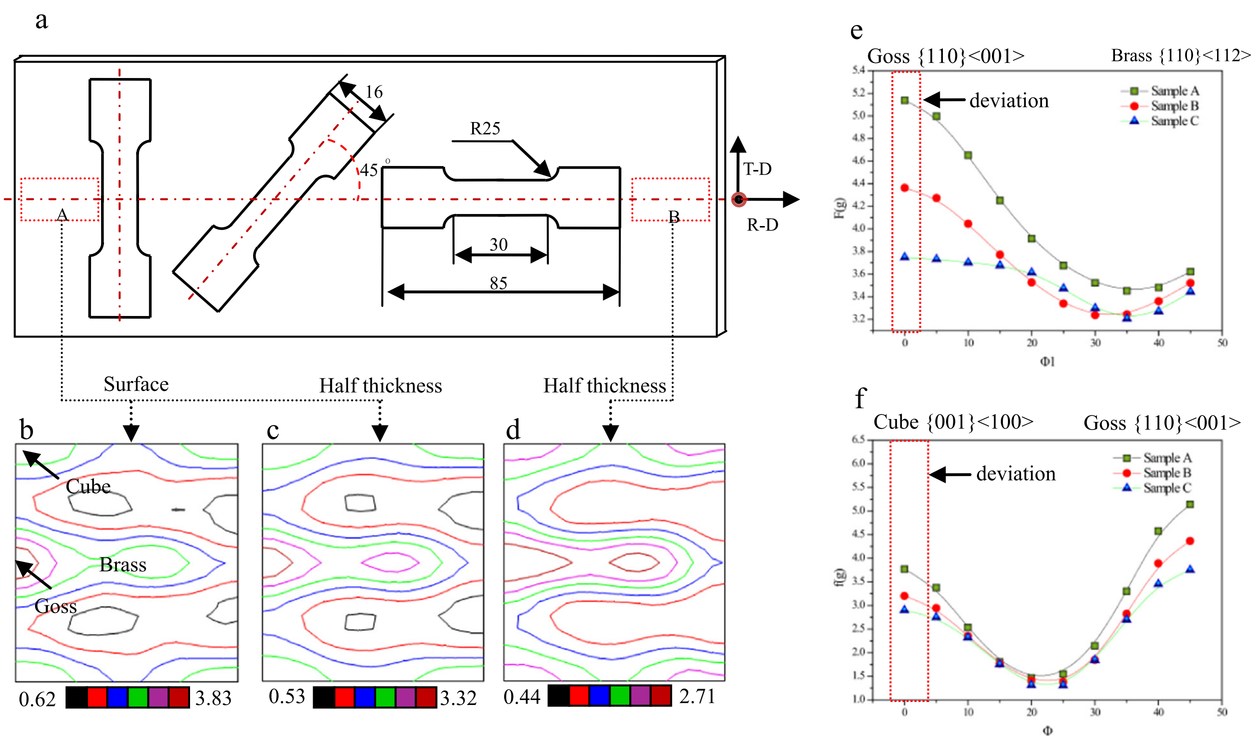


**Fig. 2.** Schematic diagram of tensile test specimens (a), ODF maps ($\varphi_2$=90°, $I_{max}$=22) of 2524 T3 sheet samples (b) at the surface (position A) and half thickness at (c) position A, and (d) position B, as well as the corresponding texture intensities along (e) the α-fiber and (f) Cube-Goss direction. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

**Table 1**
Corresponding volume fraction and intensity of the texture components in Fig. 2.

| Region | Volume fraction of texture (%) | | | Deviation | Rank | Intensity of texture component | | | Deviation | $F_{CGB}$ | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Brass | Goss | Cube | | | Brass | Goss | Cube | | | |
| A | 10.29 | 7.28 | 10.21 | 15.86 | BCG | 3.451 | 5.137 | 3.766 | 0° | 1.09 | GCB |
| B | 16.41 | 7.63 | 9.11 | 17.11 | BCG | 3.244 | 4.363 | 3.202 | 0° | 0.99 | GBC |
| C | 17.19 | 6.40 | 9.09 | 18.03 | BCG | 3.205 | 3.748 | 2.899 | 0° | 0.90 | GBC |

using conventional volume fraction, owing to the inconsistency of controlling deviations and algorithm calculations.

Fortunately, Engler et al [11,12]. have reported a relationship between the ratio of the Cube texture component and R-orientation volume fraction, and the cold rolling deformation level in commercial purity aluminum.

To complete and complement that analysis, this paper discusses the semi-quantitative relationship between the texture components and the anisotropy of yield strength in 2524 Al-Cu-Mg T3 alloy sheets using the factor $F_{CGB}$, which is based on the ratio of texture intensity at the standard positions of Cube, Goss, and Brass texture components. Furthermore, this approach would be verified and applied in other aluminum alloys.

## 2. Materials and methods

The AA2524 (Al-Cu-Mg) T3 sheets used in this study had a nominal composition of 4.2% Cu, 1.4% Mg, 0.56% Mn, 0.08% Fe, 0.06% Si, and Al as rest (all in wt%). Different hot-rolling