Supplementary S1

According to Schmid law, yield stress is inversely proportional to the SF. At the same time, experimental alloy with heterogeneous structure exhibits strong fiber texture, SF is highly dependent on the orientation [30]. Thus, theoretical calculation of SF is carried out to reveal the variation trend of yield strength. In the present work, as the variation trend of yield strength is to be discussed, commonly observed deformation mechanisms during yielding of Mg alloys at room temperature include basal slip ({0002}<11$\bar{2}$0>), prismatic slip ({10$\bar{1}$0}<11$\bar{2}$0>), and extension twinning ({10$\bar{1}$2}<10$\bar{1}$1>) are considered in the calculation[31], left deformation modes like pyramidal <a> slip, first-order pyramidal <c+a> slip, second-order pyramidal <c+a> slip, and compression twinning with high critical resolved shear stress (CRSS) are not considered[13,32].

As shown in Figure S1(a), a three-dimensional Cartesian coordinate system with z-axis paralleling to the ED is established, and loading direction (F) marked by purple arrow is located in the z-y plane. In this case, θ represents the loading angle. It is concluded from the macro texture that extruded experimental alloy has a strong <10$\bar{1}$0> fiber texture, then 3D orientation of the HCP unit cell is inserted in Figure S1(a) to show the fiber texture directly. Initial orientation (0°, 0°, 0°) defined by macro-texture measurement is depicted in Figure S1(b). For the unit cell of the initial orientation, a2 ([$\bar{1}$2$\bar{1}$0]) and c axis ([0001]) are parallel with the y and z axis, respectively. a1([2$\bar{1}\bar{1}$0]) rotates 30° counterclockwise to the x axis. Table S1 shows the expressions of the three basal slip slips, three prismatic slips and six {10$\bar{1}$2} twinning variants in the established Cartesian coordinate system. According to the definition of SF, SF is defined as:

$$\mathrm{SF} = \cos\alpha * \cos\beta \quad (1)$$

Where α is the angle between the loading axis and normal direction of slip or twinning plane, β is the angle between loading direction and slip or twinning shear direction. Taking the loading direction into consideration, Equation (1) can be further written as:

$$\mathrm{SF} = (\overrightarrow{F_0}\cdot\overrightarrow{n_0})*(\overrightarrow{F_0}\cdot\overrightarrow{s_0}) \quad (2)$$

Where $\overrightarrow{F_0}$, $\overrightarrow{n_0}$ and $\overrightarrow{s_0}$ are the unit vector of loading direction, normal direction of slip or twinning plane, and slip or twinning shear direction, respectively. According to the schematic diagram shown in Figure S1(a), loading vector is expressed as:

$$\vec{F} = F(0\ sin\theta\ cos\theta)^{\mathrm{T}} \quad (3)$$

F represents the loading value, θ is the loading angle defined in Figure S1(a), which ranges from 0° to 90°. Then the unit vector of $\vec{F}$ is written as:

$$\overrightarrow{F_0} = (0\ sin\theta\ cos\theta)^{\mathrm{T}} \quad (4)$$

SF calculation by using Equation (2) is valid only for the initial orientation. Due to the existence of <10$\bar{1}$0> fiber texture, Euler angles and Bunge notation are used to rotate the grain orientation into the established Cartesian coordinate system[33]:

$$\vec{n} = \boldsymbol{G}*\overrightarrow{n_0} \quad (5)$$

$$\vec{s} = \boldsymbol{G}*\overrightarrow{s_0} \quad (6)$$

G is the rotation matrix determined by the texture.

By taking Equation (5) and (6) into Equation (2), SF can be calculated. In addition, for the three basal slip systems and prismatic systems, SF with the maximum value is taken as the activated deformation mode. Because of the polar nature of the {10$\bar{1}$2} twinning in

Mg alloys, twinning shear is directional, and it can occur only in one direction rather than the opposite direction[34]. Namely, positive value of SF indicates $\{10\bar{1}2\}$ twinning can be only activated during tension, otherwise it can be activated during compression. As there are six $\{10\bar{1}2\}$ twinning variants, at most 6 sets of data will be calculated for one orientation, and they are divided into two groups based on positive and negative values. SF of twin variants with positive value is considered to be activated during tension, and SF with maximum value is selected and plotted in the map. Otherwise, SF of twin variants with negative value is considered to be activated during compression, and SF with maximum absolute value is selected and plotted in the map. Moreover, as the SF will be influenced by the φ_1 and loading angle θ, and the present work is to illuminate the variation trend between the SF and θ, average SF under each φ_1 are counted and depicted in Figure 9(a) at 1° interval of θ.

According to the definition of critical resolved shear stress, the ratio of CRSS/SF is used to measure the activated stress of each deformation, so as to qualitatively assess which deformation mode is likely to be activated. M.R. Barnett and Z. Zhang et al. have already used the ratio of CRSS/SF to identify the activated deformation mode in Mg alloys[15,35]. CRSS of deformation modes are un-known in the experimental alloy, our previous study has confirmed that Gd addition has little effect on the texture due to the formation of secondary phases which consumes the added Gd[12]. Therefore, it is reasonable to deduce that added Gd may have little effect on the CRSS of deformation modes in the present work. In this case, CRSS value calculated in wrought Mg-Zn based alloys, which have similar composition and texture with the experimental alloy, can be used here to qualitatively evaluate the possibility of activated slip systems. J.H. Cho et al calculated the CRSS ratio between basal slip, prismatic slip and $\{10\bar{1}2\}$ twinning in the extruded Mg-5.47Zn-0.58Zr (wt%) alloy by using viscoplastic simulation[36]. Ratio value of 11:45:16 given in their work is used here to calculated value of CRSS/SF, then the relationship between the CRSS/SF and the loading angle is plotted in Figure 9(b).

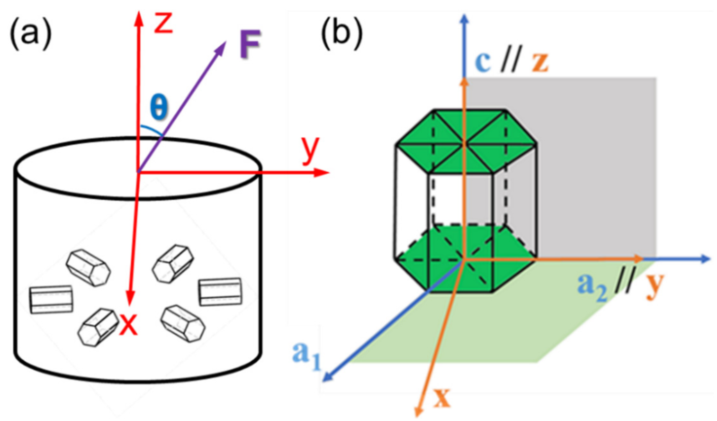

Figure S1. (a) Location relationship between the loading axis and the grain orientation, (b) initial orientation in the three-dimensional Cartesian coordinate system

Table S1. Translation of Hexagonal Miller-Bravais indices of basal slip system, prismatic slip system and extension twinning between Cartesian system

Type	Hexagonal	Cartesian	Type	Hexagonal	Cartesian
Basal <a>	(0001)	(001)	Prismatic	(10$\bar{1}$0)	(100) [010]
	[2$\bar{1}\bar{1}$0]	[0.866 -0.5 0]	<a>	[$\bar{1}$2$\bar{1}$0]	
	(0001)[$\bar{1}$2$\bar{1}$0]	(001)[010]		(0$\bar{1}$10)	(-0.5 -0.866 0)
				[2$\bar{1}\bar{1}$0]	[0.866 0.5 0]
	(0001)[$\bar{1}\bar{1}$20]	(001)		($\bar{1}$100)	(-0.5 0.866 0)
		[-0.866 -0.5 0]		[$\bar{1}\bar{1}$20]	[-0.866 -0.5 0]
{10$\bar{1}$2}	(10$\bar{1}$2)[$\bar{1}$011]	(0.684 0 0.729)		($\bar{1}$012)	(-0.684 0 0.729)
twinning		[-0.729 0 0.684]		[10$\bar{1}$1]	[0.729 0 0.684]
	(01$\bar{1}$2)[0$\bar{1}$11]	(0.342 0.592 0.729)		(0$\bar{1}$12)	(-0.342 -0.59 0.729)
		[-0.365 -0.63 0.684]		[01$\bar{1}$1]	[0.365 0.632 0.684]
	($\bar{1}$102)[1$\bar{1}$01]	(-0.342 0.592 0.729)		(1$\bar{1}$02)	(0.342 -0.59 0.729)
		[0.365 -0.63 0.684]		[$\bar{1}$101]	[-0.365 0.632 0.684]