# Paragraph Ran in the Queries

**Paper Title:**Effect of cold-rolling and annealing temperature on microstructure, texture evolution and mechanical properties of FeCoCrNiMn high-entropy alloy
**Content :**

## Introduction

FeCoCrNiMn high-entropy alloy (HEA), also known as Cantor alloy, is a type of equiatomic alloy with a single-phase structure, introduced and developed by Cantor et al. [1]. Although Cantor alloys exhibit relatively low yield stress (≈300 MPa) and ultimate tensile strength (≈500 MPa) at room temperature, Gludovatz et al. have demonstrated that the strength and fracture toughness of Cantor alloys can surpass those of existing conventional cryogenic materials at liquid nitrogen temperatures and even lower [[2], [3], [4]]. The exceptional ductility and strength at low temperatures present Cantor alloys as having significant potential in fields such as deep space exploration, superconducting applications, particularly in gas transport and storage [4,5].

Traditional low-temperature structural materials, such as austenitic stainless steel, TWIP steel, and nickel-based alloys, inevitably undergo cold rolling and annealing processes. As the new generation of materials used in low to ultra-low temperature environments, studying the microstructural and texture evolution of Cantor alloys during cold rolling and annealing is directly related to process optimization, quality control, and material performance. Much research has been conducted on the cold deformation and annealing textures of austenitic stainless steel, TWIP steel, and nickel-based alloys [[6], [7], [8], [9]]. However, there are a few studies on the microstructural and texture evolution of Cantor alloys during cold rolling and annealing.

Bhattacharjee et al. [10] found that FeCoCrNiMn forms a strong Brass-type texture after 90% cold rolling deformation, and a weak randomly distributed annealing texture after annealing at 650–1000 °C. Similar to Bhattacharjee's findings, Sathiaraj et al. [11] also indicated that FeCoCrNiMn forms a Brass-type texture under significant cold rolling deformation. Saha et al. [12] studied the cold rolling texture of the medium-entropy alloy (MEA) CoCrNi and found that after cold rolling, CoCrNi forms a strong Brass texture, and the presence of high-density interwoven shear bands seems to weaken this Brass texture. Research by Wang et al. [13] indicates that in NbC reinforced FeCoCrMn HEAs, the intensity of Brass and A texture components is greatest during cold rolling, and recrystallization is more likely to occur in areas of high strain. The above findings suggest that the evolution of cold rolling and annealing textures in medium- or high-entropy alloys composed of elements such as Fe, Co, Cr, Ni, and Mn might be similar to that of austenitic stainless steels or TWIP steels with low stacking fault energy (SFE), rather than nickel-based alloys with high SFE.

In recent years, research on Cantor alloys has mainly focused on uncovering the microscopic mechanisms behind their excellent low-temperature mechanical properties or on continuously exploring various methods to enhance the room-temperature mechanical performance of single-phase Cantor alloys [14,15]. These methods include adding interstitial atoms [16], severe plastic deformation [17], and precipitation hardening [18]. The drop in ambient temperature leads to a sharp decrease in the SFE of Cantor alloys, making the material more prone to martensitic transformation, formation of nanoscale mechanical twins, and planar slip, all of which contribute to the superior low-temperature mechanical properties [15,19,20]. Unlike the deformation behavior of materials at low temperatures, the effects of room-temperature cold rolling and annealing processes on the mechanical properties of Cantor alloys are related to dislocation slip and recrystallization.

Although some researchers have demonstrated that the texture types formed during the cold rolling and annealing of medium or high entropy alloys composed of elements like Fe, Co, Cr, Ni, and Mn are similar to those of austenitic stainless steel and TWIP steel, there has been no analysis or in-depth discussion on why FCC high entropy alloys exhibit Brass-type texture evolution. Moreover, no comparative analysis has been conducted with austenitic stainless steel or TWIP steel. In this study, we compared the similarities and differences in the microstructure and texture evolution of the new-generation low-temperature material (FeCoCrNiMn) with traditional low-temperature materials such as austenitic stainless steel and TWIP steel after cold rolling and annealing, and revealed the fundamental reasons for the texture evolution of FeCoCrNiMn alloy. Furthermore, we studied the impact of cold rolling and annealing on the mechanical properties of FeCoCrNiMn alloy, analyzing its dislocation slip characteristics during cold rolling and the recrystallization behavior during annealing. The results of this study not only advance the further application of HEAs in low-temperature environments but also contribute to the development and innovation of new materials to meet the needs of different application areas.

## . Mechanical properties evolution

Fig. 11(a) presents the engineering stress-strain curves for the FeCoCrNiMn after uniaxial tensile testing, conducted post-cold rolling and annealing. From these curves, the yield strength, tensile strength, and elongation, can be obtained in Fig. 11(c). The results in Fig. 11(a) and (c) reveal that as the cold rolling reduction increases, both the yield strength and tensile strength of FeCoCrNiMn significantly improve, while elongation noticeably decreases. Compared to the undeformed state, the yield strength of the alloy increases to nearly 1000 MPa after ~66% cold rolling deformation, but the elongation is reduced to just 9%. After annealing at 600 °C for 1 h, the mechanical properties undergo minimal changes, consistent with the microscopic structural observations.