Supplementary materials

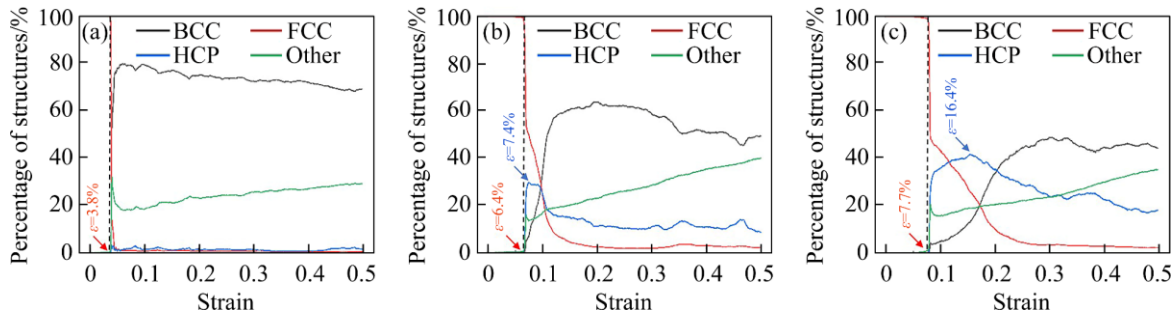

Figure S1 Percentages of different phase structures in Fe-Mn alloys with different Mn contents during tensile deformation: (a)10%Mn; (b)20%Mn; (c)30%Mn (The label "Other" represents unidentified structure)

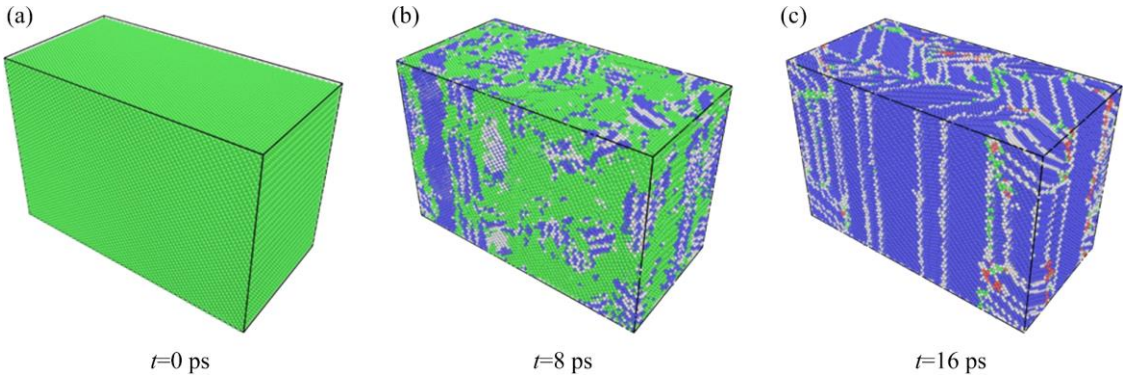

Figure S2 Microstructure evolution of pure Fe during relaxation(Atomic colors represent different phase structures: green-FCC, red-HCP, blue-BCC, and white-unrecognized)

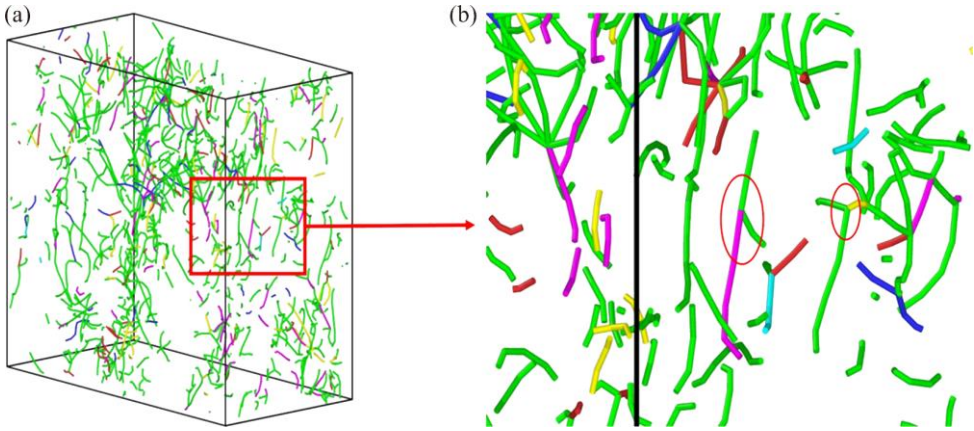

Figure S3 Interaction between Shockley partial dislocation, Stair-rod dislocation and Hirth dislocation in FCC phase in Fe-20%Mn alloy(Colors of dislocation lines represent different kinds of dislocations: green-Shockley partial dislocation, purple-Stair-rod dislocation, and yellow-Hirth dislocation)

Table S1 Variants of Burgers orientation relationship of BCC phase and HCP phase transformation [21]

Variant	Orientation relationship
1	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{2}110]_{HCP}\|\|[\bar{1}1\bar{1}]_{BCC}$
2	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{2}110]_{HCP}\|\|[\bar{1}11]_{BCC}$
3	$(0001)_{HCP}\|\|(110)_{BCC}$, $[01\bar{1}0]_{HCP}\|\|[11\bar{2}]_{BCC}$
4	$(0001)_{HCP}\|\|(110)_{BCC}$, $[01\bar{1}0]_{HCP}\|\|[\bar{1}1\bar{2}]_{BCC}$
5	$(0001)_{HCP}\|\|(110)_{BCC}$, $[1\bar{2}10]_{HCP}\|\|[1\bar{1}1]_{BCC}$
6	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{1}2\bar{1}0]_{HCP}\|\|[\bar{1}11]_{BCC}$
7	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{1}010]_{HCP}\|\|[\bar{1}12]_{BCC}$
8	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{1}010]_{HCP}\|\|[1\bar{1}2]_{BCC}$
9	$(0001)_{HCP}\|\|(110)_{BCC}$, $[11\bar{2}0]_{HCP}\|\|[\bar{1}1\bar{1}]_{BCC}$
10	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{1}\bar{1}20]_{HCP}\|\|[\bar{1}11]_{BCC}$
11	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{1}100]_{HCP}\|\|[\bar{1}12]_{BCC}$
12	$(0001)_{HCP}\|\|(110)_{BCC}$, $[\bar{1}100]_{HCP}\|\|[\bar{1}1\bar{2}]_{BCC}$

Table S2 Schmid factors for the slip systems of FCC iron in three loading directions

Slip system	$[\bar{1}\bar{1}2]$	$[1\bar{1}0]$	[111]
$(111)[0\bar{1}1]$	0	0	0
$(111)[\bar{1}01]$	0	0	0
$(111)[\bar{1}10]$	0	0	0
$(\bar{1}11)[0\bar{1}1]$	0.408	−0.408	0
$(\bar{1}11)[101]$	0.136	−0.408	0.272
$(\bar{1}11)[110]$	−0.272	0	0.272
$(1\bar{1}1)[011]$	0.136	−0.408	0.272
$(1\bar{1}1)[\bar{1}01]$	0.408	−0.408	0
$(1\bar{1}1)[110]$	−0.272	0	0.272
$(11\bar{1})[011]$	−0.272	0	0.272
$(11\bar{1})[101]$	−0.272	0	0.272
$(11\bar{1})[\bar{1}10]$	0	0	0