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## ABSTRACT

Grain refinement of non-equiatomic Cr-rich CoCrFeMnNi high-entropy alloys with an fcc structure was studied focusing on the precipitation of a Cr-rich  $\sigma$  phase along grain boundaries and shear bands. We found for the first time that the  $\sigma$  phase can be precipitated at the grain boundaries and the shear bands in the alloys at a significantly fast precipitation rate. The  $\sigma$  phase effectively suppressed the grain growth of the fcc matrix during recrystallization of the alloy after conventional cold rolling, resulting in a fine-grained microstructure with a mean diameter of approximately 1  $\mu\text{m}$ . The alloys with this fine microstructure containing the  $\sigma$  phase exhibit high strength over a wide

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