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Effect of Grain Refinement on the Corrosion and Wear Behavior of HPT-Processed $Cr_{40}Co_{40}Ni_{20}$ Alloy

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Introduction and objective

$Cr_{40}Co_{40}Ni_{20}$ is a medium-entropy alloy with a metastable FCC matrix that transforms to HCP under strain [1] and forms a protective passive film [2]. High-pressure torsion (HPT) strongly hardens such alloys [3], but the defects and phases it creates may also alter passivity.

Objective: assess how the number of HPT turns (¼, 1 and 10) changes the microstructure, hardness, scratch wear and corrosion behavior of the alloy.

Methodology

$Cr_{40}Co_{40}Ni_{20}$ – homogenized (1100 °C, 2 h) → hot + cold rolled → recrystallized (1050 °C, 0.5 h)

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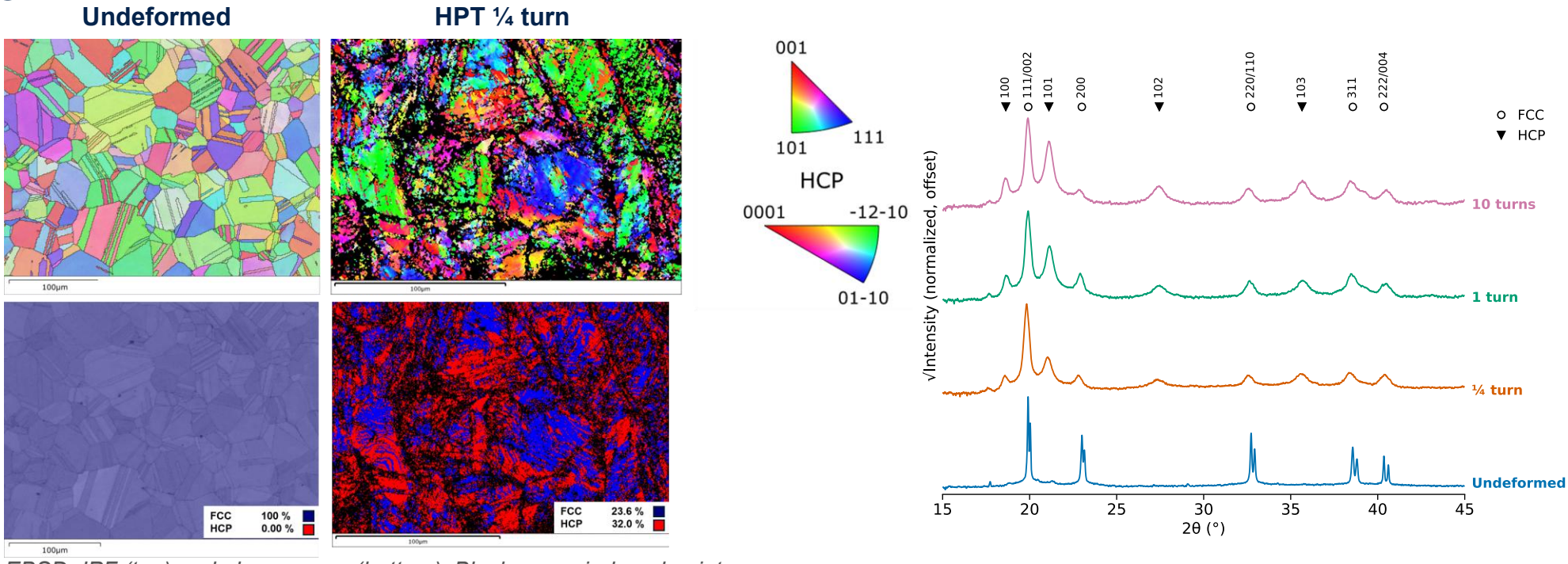
HPT: 6 GPa, 1 rpm, 300 K – N = ¼, 1, 10 turns

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Characterization: EBSD, XRD · Vickers maps (HV0.5) · progressive scratch (5–30 N) · EIS + cyclic polarization in 0.6 M NaCl

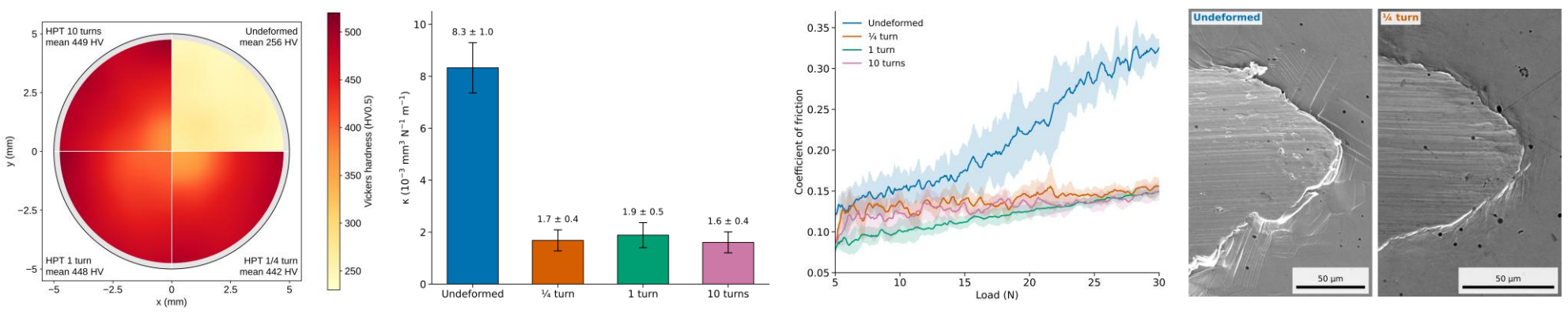
Results and discussion

① HPT triggers a strain-induced FCC → HCP transformation (HCP: 0 → 47 → 62 % by XRD)

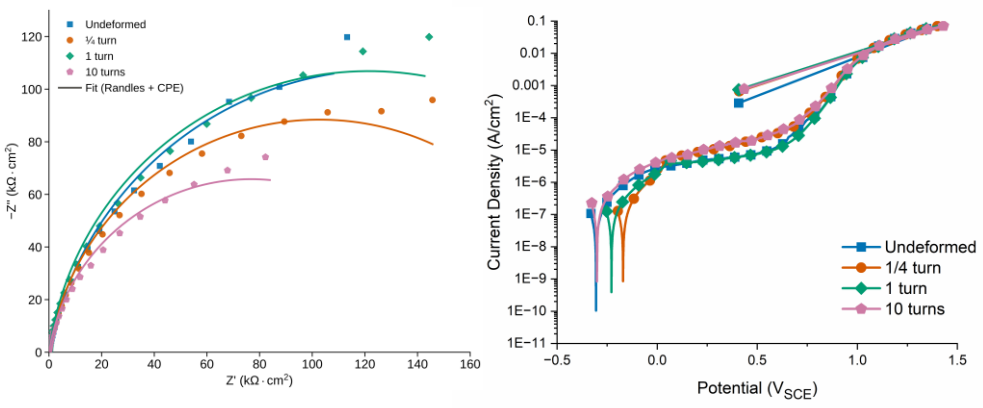


EBSD: IPF (top) and phase maps (bottom). Black = non-indexed points.

② Hardness rises ~75 % (256 → ~445 HV) already after ¼ turn, and the wear rate drops ~5×



③ Passivity is preserved: similar i_{pass}, breakdown in the transpassive region and R_p of the same order



	Cyclic polarization				EIS (Randles + CPE)	
	E_{corr} (mV_{SCE})	i_{pass} ($\mu A \cdot cm^{-2}$)	E_{transp} (mV_{SCE})	$E_{transp} - E_{corr}$ (mV)	R_p ($k\Omega \cdot cm^2$)	α_{CPE}
■ Undeformed	−284 ± 45	7.3 ± 3.2	632 ± 20	916 ± 31	272 ± 21*	0.879 ± 0.011*
● ¼ turn	−149 ± 25*	9.4 ± 1.2*	695 ± 26*	845 ± 51*	219 ± 30	0.911 ± 0.006
◆ 1 turn	−282 ± 50	9.0 ± 3.7	629 ± 54	910 ± 58	319 ± 66	0.926 ± 0.008
⬟ 10 turns	−266 ± 28	8.8 ± 2.6	676 ± 32	943 ± 54	179 ± 47	0.900 ± 0.002

Mean ± standard deviation (n = 3). * n = 2 (one replicate discarded).

Conclusions

- Hardness saturates (~445 HV, +75 %) after only ¼ turn, while the HCP fraction keeps growing.
- Wear rate falls ~80 % and the friction coefficient at 30 N is halved after HPT.
- Passivity is kept: i_{pass} = 7–9 $\mu A \cdot cm^{-2}$ and E_{transp} = 630–700 mV_{SCE} in all conditions.
- **HPT improves wear resistance without compromising corrosion resistance.**

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References and acknowledgements

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