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Effect of cold-working and annealing on the electrochemical behavior of the 304L austenitic stainless steel in saline media.

Bachani Mokded¹, Hayoune Abdelali¹, Fajoui Jamal², Dubos Pierre – Antoine².

Introduction

Cold-rolling (CR) is a widely used process to obtain Ultrafine-grained (UFG) bulk 304L stainless steel for the aim of enhancing its mechanical characteristics. The method is based on the formation of deformation-induced martensite (DIM) with ultrafine size, and then annealing it at a specific temperature to reverse the formed DIM into UFG austenite[1]. Studies have shown an improvement in mechanical properties[1]. However, no clear electrochemical behavior of the cold rolled material in a saline media.

Objectives

- Investigate the effect of the cold rolling rate on the electrochemical behavior of 304L in both rolling direction (RD) and normal to rolling direction (NRD) surfaces.
- Investigate the effect of reversion annealing on the electrochemical behavior of 304L in both RD and NRD surfaces.

Methods and materials

1 Sample preparation

Cold-rolling:

- 304L samples were cold rolled at room temperature into 50% and 80% reduction thickness rates. XRD show that the none-deformed sample have 0% DIM, 50% CR sample formed 62.67% DIM and , and 80% CR sample formed 83.61% DIM.

Reverse annealing:

- The cold rolled samples were annealed at 660°C and 850°C, under a medium vacuum. XRD shows that after annealing at 660°C the 50% CR sample has 44.06% of DIM, and the 80% CR sample has 63.39% of DIM. And all the formed DIM were reversed into austenite at 850°C for both CR samples.

2 Potentiodynamic polarization

- The samples were potentiodynamic polarized around the corrosion current in a 0.6M NaCl solution after being electropolished to remove any possible formed oxide film. The none-concerned sample surfaces were covered.

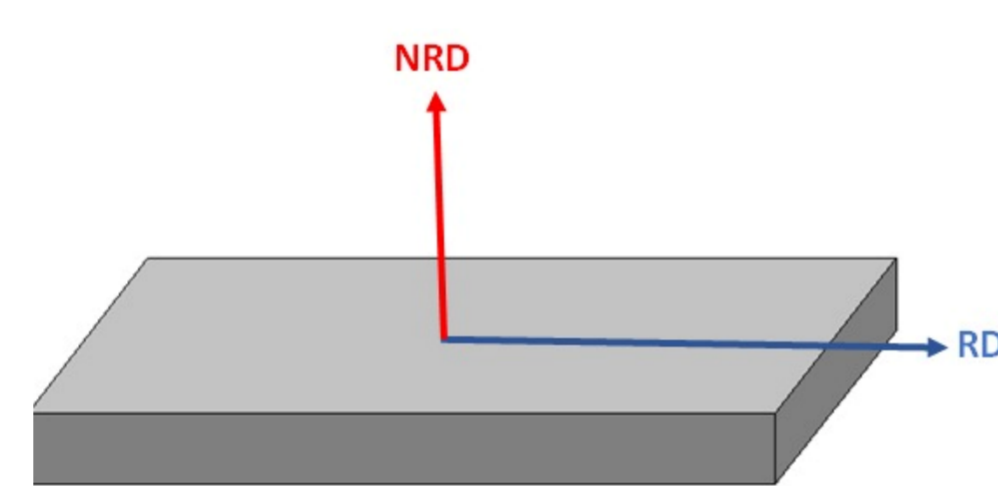
3 Data analysis

$$V_{\alpha'} = \left(1 + \frac{I_{hkl}^{bcc} R_{hkl}^{FCC}}{I_{hkl}^{FCC} R_{hkl}^{bcc}} \right)^{-1}$$

$V_{\alpha'}$ is the volume fraction of DIM, I is the integrated intensity, R is the scattering factor.

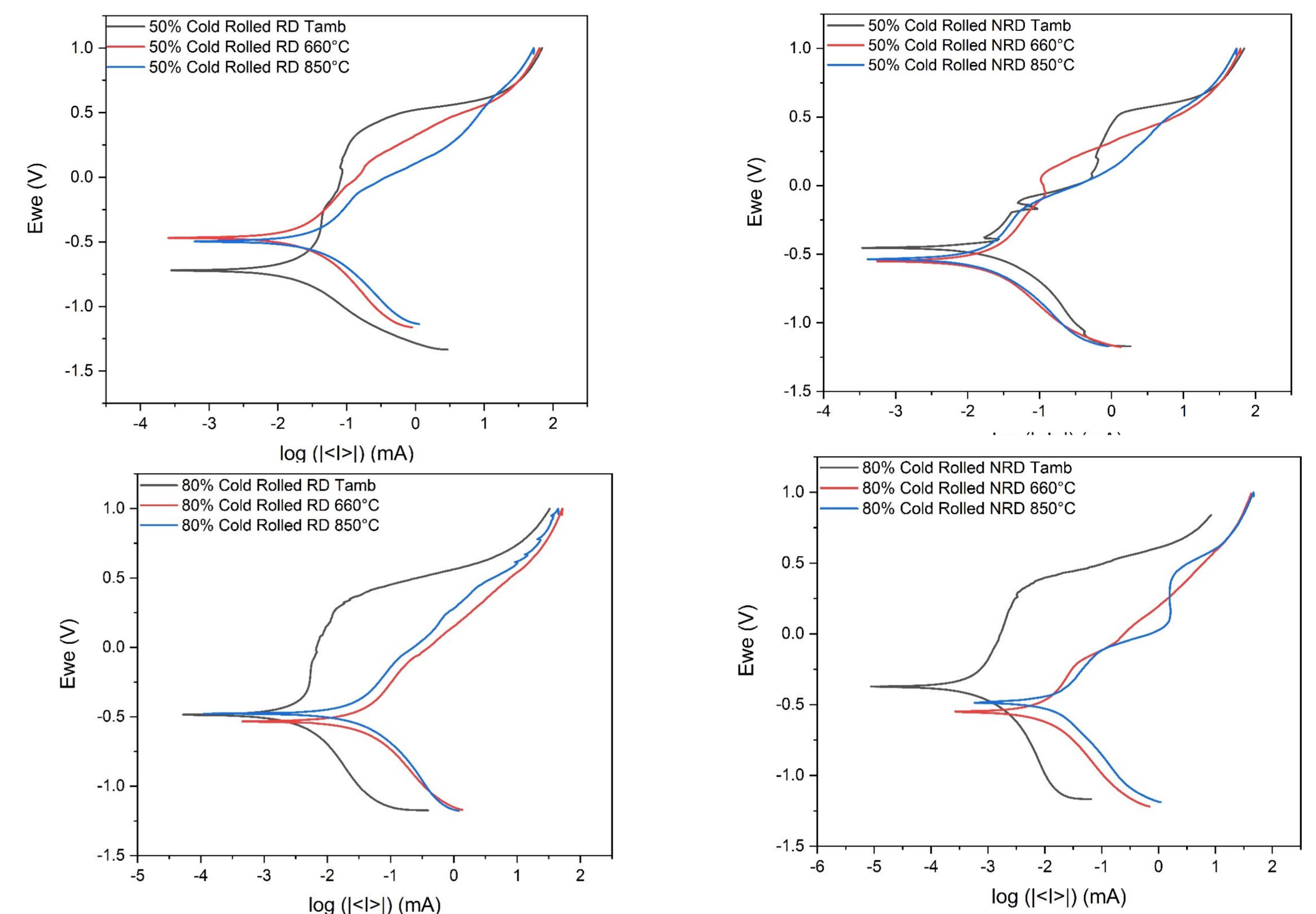
• **Passive film thickness estimation**[2]: $d = \frac{A * \epsilon * \epsilon_0}{c}$.

A is the area of the working electrode, ϵ is the dielectric constant of the passive film[3], ϵ_0 is the vacuum permittivity, C is the total capacitance of the passive film from current density-time curve.

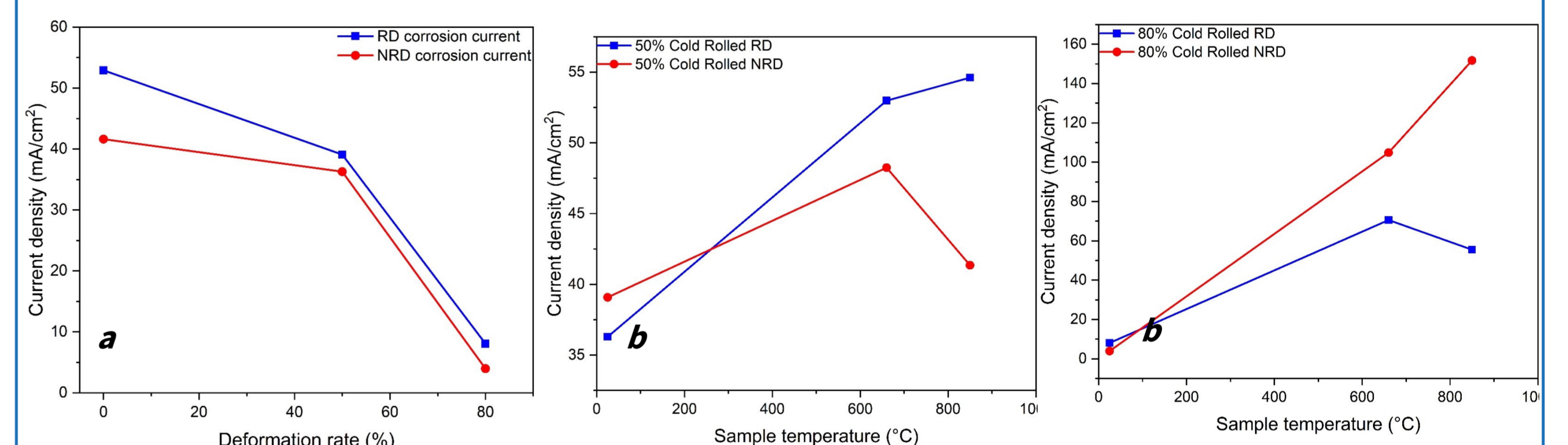


Results

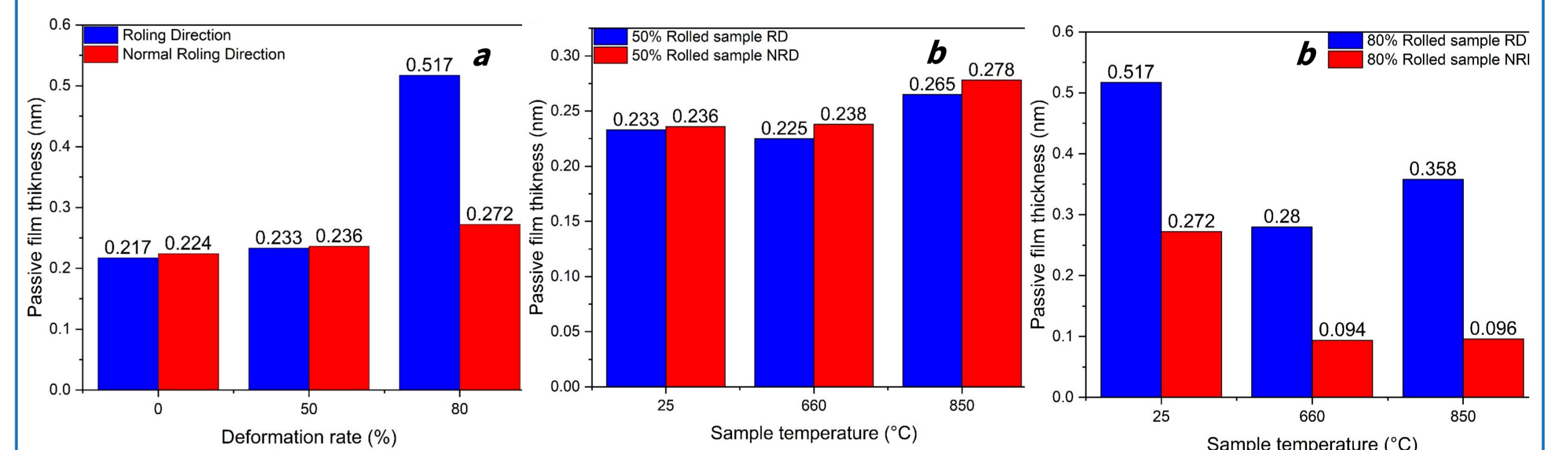
Potentiodynamic polarization



Potentiodynamic polarization of cold rolled samples vs annealing temperature



Corrosion current density vs a) deformation rate b) annealing temperature



Passive film thickness vs a) deformation rate b) annealing temperature

Conclusion

- CR enhanced the corrosion resistance of both RD and NRD surfaces, even after annealing.
- At a low deformation rate, the passive film grows equally on RD and NRD surfaces, but at an extensive deformation rate, the growth of the passive film of RD is nearly double the growth of the NRD.
- At low temperatures, the corrosion resistance is proportional to the passive film thickness, but not at high temperatures.

[1] Nagy, E., Mertinger, V., Tranta, F., Sólyom, J., 2004. Materials Science and Engineering: A 378, 308–313.

[2] Chen, J., Wang, J., Han, E., Dong, J., Ke, W., 2008. Corrosion Science 50, 1292–1305.

[3] Escrivà-Cerdán, C., Blasco-Tamarit, E., García-García, D.M., García-Antón, J., Guenbour, A., 2012. Electrochimica Acta 80, 248–256.

