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Are plasma nitriding treatments effective in changing wettability and evaporation of sessile water droplets on austenitic stainless steel surfaces?

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Wetting and evaporation of sessile droplets on engineered surfaces is now intensively studied. So, improving phase change heat transfer is important to meet the rising global energy demand in a sustainable manner in various industrial applications: thermal generation of electricity, electronics cooling, heat exchangers. Plasma nitriding is widely used to improve the surface properties of steels and is an attractive way to increase the durability of patterned steels. Strangely, the wettability of nitrided surfaces is poorly studied. The purpose of this communication is to study the ability of nitriding treatments in modifying the wetting and evaporation of sessile droplets on AISI 316L. The use of a multi-dipolar plasma coupled to substrate heating device for the nitriding treatment provides independent substrate biasing. It is thus possible to tailor the surface before and during the nitriding treatments. Wettability is extremely sensitive to the surface conditions, both from a chemical and topographical point of view. As it will be shown in this communication, a nitriding treatment can induce both types of modifications. Thus, for a 1 ml of pure water, the contact angle measured on a freshly polished surface of AISI 316L is 40 °. If this surface is exposed to air for several days, it loses part of its hydrophilicity and the contact angle turns to 60° or even more. The cleaning treatment (Ar-H_2 plasma), carried out before nitriding treatments, produces topographical modifications of the surface by selective sputtering of the grains. It is thus possible to reach contact angles between 80 and 90 °. We obtain similar results when the nitriding treatments are carried out with a rather high bias (-200 V). For nitriding treatments carried out with lower bias (between 0 and -50V), surface contamination occurs and a discontinuous oxide layer is formed. The characterization by TEM of these oxides shows that they are amorphous and made up only of iron. The nanostructure formed by these oxides gives contact angles up to 120 °. Finally, controlled polishing of the surface of the nitrided samples eliminates any physical contribution to wettability. Thus, an intrinsically hydrophylic chemical behaviour (contact angle 35 °) of the nitrided layer is highlighted.

Keywords
wettability, nitriding, plasma cleaning,evaporation, stainless steel