Effect of various surface modification techniques on the wettability properties of shape memory alloys

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Motivation

Nickel-Titanium or NiTi is one of the most widely used alloys with shape memory effect (SMA), relevant for industries such as aerospace, automotive, biomedical and others. In recent years, the efficient mitigation of icing hazards has become of interest for many applications. Ice formation may cause system performance reduction and various damages, leading to economic consequences and safety issues.

Therefore, the design of materials with *reduced ice accretion and adhesion* is crucial for aerospace and energy systems. The results of the characterization of SMA surfaces subjected to various thermo-mechanical modifications (including chemical etching and laser surface texturing) are presented in terms of surface roughness and its effect on the interaction with water, in view of evaluating the ice-surface interaction.

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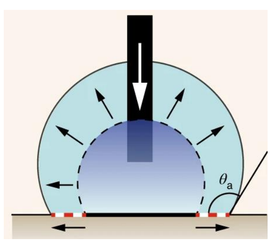
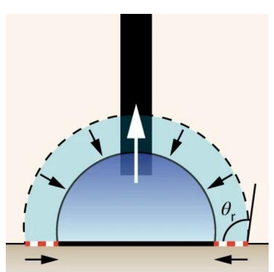
Wettability properties: Contact angle measurements[1]



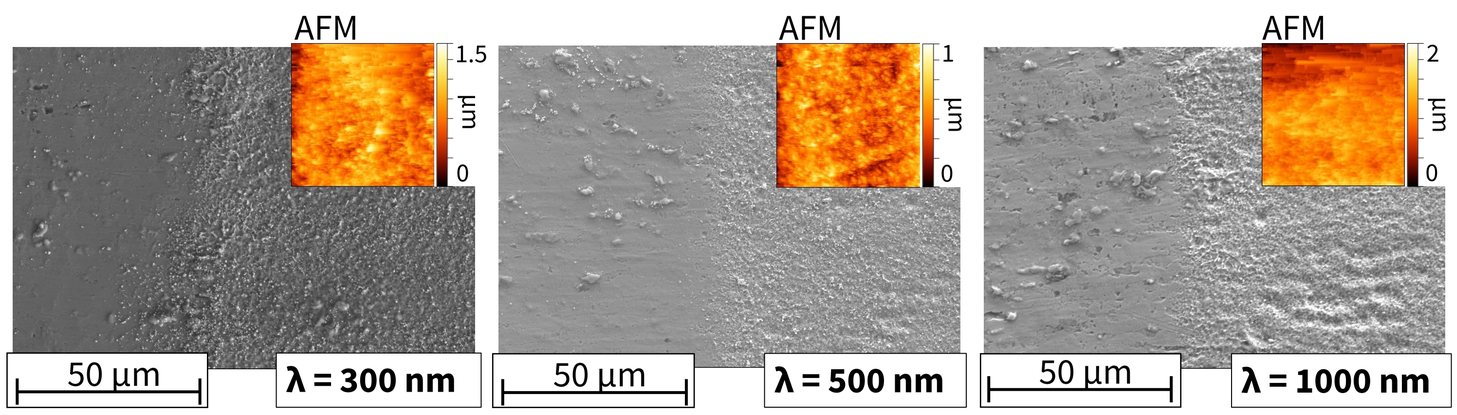
Advancing CA
Water contact angle (WCA) in course of a wetting process.

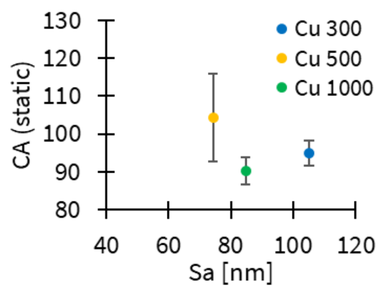


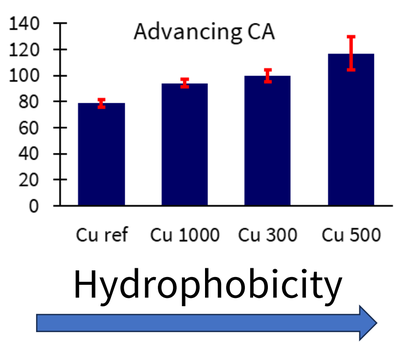
Receding CA
WCA during the de-wetting process.

Adapted from: DOI: 10.1038/s41596-018-0003-z

Cu based - Femtosecond laser ablation[2]



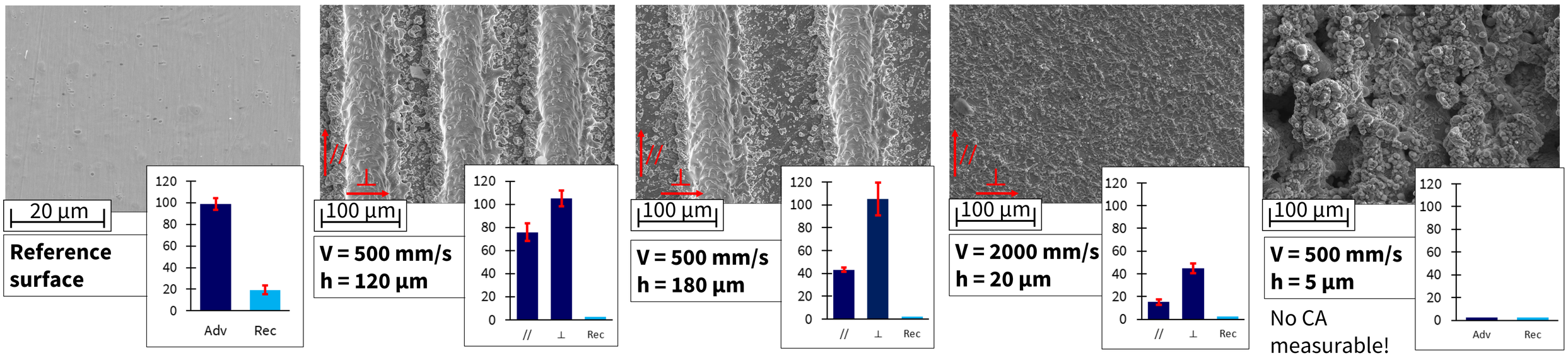




Hierarchical micro- and nano-structuring resulting in hydrophobic Cu-based SMA surfaces can be achieved with femtosecond pulsed laser treatment. The relationship between surface roughness and wettability is not straight-forward. Similar roughness (Sa) values can result in different contact angle values.

NiTi based - Nanosecond laser ablation

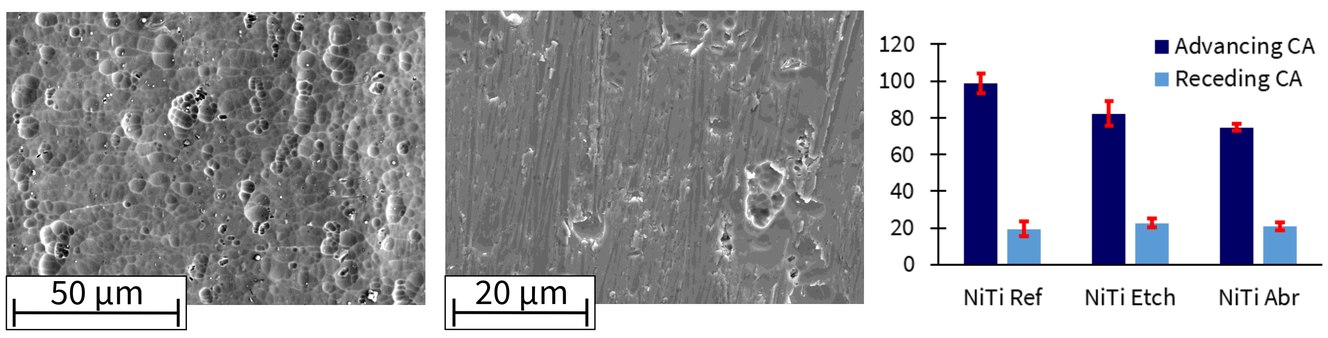
Laser parameters: Power = 30 W, Frequency = 100 kHz, Pulse duration = 200 ns



- Depending on laser patterning strategies, anisotropic wetting properties can be obtained
- Oxide formation can increase the wettability.

Increasing hydrophilicity

NiTi based - Chemical etching and mechanical abrasion



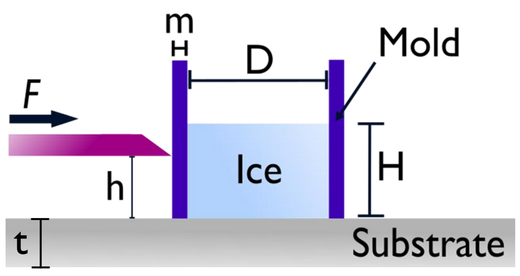
Pickling solution (v/v): H_2O 50%, HNO_3 40 %, HF 10%

Wet sandpaper abrasion: Grit 1200

Hydrophilicity

In the absence of oxidation phenomena and for the tested surface morphologies, a stable receding contact angle can be observed.

Conclusions and perspectives[3],[4]



We show how various chemical, mechanical, and laser surface treatments can tune the wettability of NiTi- and CU-based SMA, obtaining both hydrophobic and hydrophilic substrates.

The feasibility of laser texturing for ice adhesion reduction on Cu- and NiTi-based substrates will be investigated. Additionally, the interplay of substrate thickness and recalescent heat release will be studied and exploited for the fabrication of low ice adhesion surfaces based on NiTi shape memory alloys.

References

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