Strongly anisotropic wetting on highly-uniform self-similar molybdenum nanogrooves

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Nanostructure formation through surface treatment is mostly performed with well-established techniques including lithography and laser-induced periodic surface structuring (LIPSS). However, these techniques suffer either from the limited flexibility, high-cost, complex equipment, or suffer from the low-speed, problems of material control, and lack of uniformity and repeatability over large areas. Recently, a technique called Nonlinear Laser Lithography (NLL) was introduced, which allows fabrication of extremely uniform nanostructures, with excellent long-range repeatability and at high-speeds [1]. NLL can be applied to a variety of materials, including non-planar, even flexible surfaces. While NLL generates essentially LIPPS-type of nanostructures, it does so by utilizing nonlinear feedback mechanisms arising from the interaction of femtosecond laser pulses with the target surface, as well as from the laser-initiated chemical reaction. Key features, such as superior uniformity and ability to process non-flat surfaces are a direct consequence of the self-regulation provided by these feedback mechanisms.

Applications of surface-treated nanostructures have been demonstrated in various fields including electronics, optoelectronics, photovoltaics. Although the outcomes are encouraging, because of the problems of material and process control, they are still not suitable for transfer to industrial applications. It is appears that these problems can be overcome by NLL-induced nanostructures, thanks to their aforementioned superior features, with potential for substantial impact in these and related fields. However, the technique is new and its potential for these applications needs to be evaluated systematically.

Here, we report on highly uniform, anisotropic, periodic molybdenum nanogrooves fabricated through NLL (Figure 1). We investigate the wettability characteristics of the nanogrooves as a strong candidate to be used for applications where anisotropic wetting of the surfaces is favored, ranging from microfluidics to energy applications to biomedical research such as gas seal conditions, self-cleaning surfaces, directional syringes, microprocessor cooling, high-efficiency hydropower turbines, and nanoscale digital fluidics. Wettability is investigated through contact angle measurements, where sessile drop methodology is used with distilled-deionized water as the test liquid. It is shown that the nanogrooves improved the hydrophilic behavior of the flat molybdenum surface significantly. Moreover, better wetting of the surface along the nanogrooves is observed. It is also shown that we can tune the wettability behavior, where the transition from Wenzel to Cassie regime is observed.

[1] B. Oktem, I. Pavlov, S. Ilday, H. Kalaycıoglu, A. Rybak, S. Yavas, M. Erdogan, & F. O. Ilday, Nat. Photonics **7** (2013) 897.

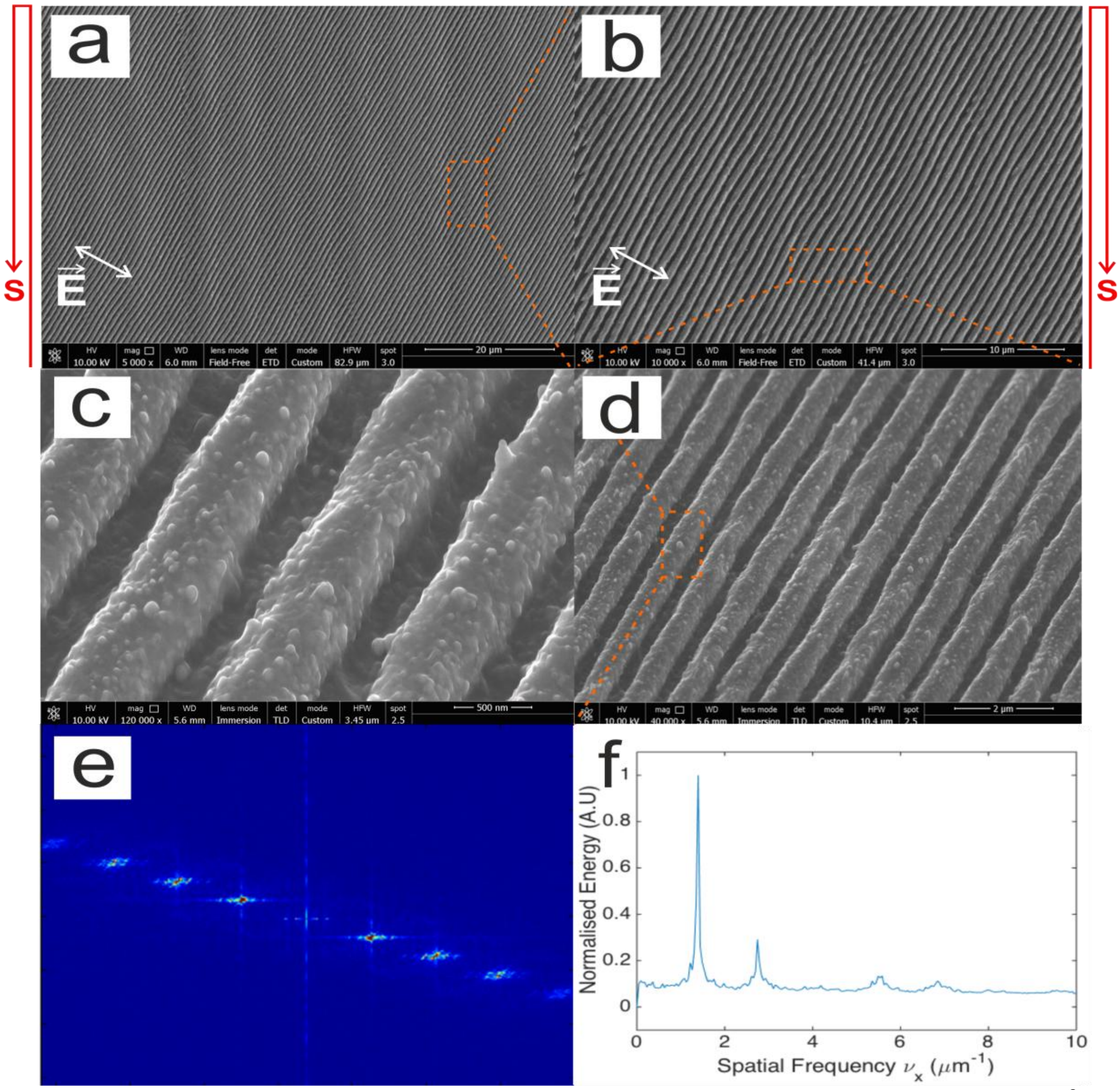

Fig. 1. SEM images of the Molybdenum surface ablated by fs-laser pulses at fluence of 0.7 J/cm^2. (a) Nanotextured sample at a 100 mm/s scan speed.(b) Higher magnification image, (c and d) represent higher magnification image of (a), tilted on 45º of (a).(e, f) shows the 2D FFT and 1D FFT images of the micrograph (b).