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Nanoscale masking with UV excimer laser for bit patterned media

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In order to pass recent thin film media, bit patterned media (BPM) is a promising candidate for future high density magnetic recording. In spite of a decrease of the domain size, the thermal stability can be improved and media transition noise reduced. There are several techniques targeting the 1 Tbit/inch^2 density (~25 nm dot size) such as electron beam lithography, nanostamping and colloid chemical methods. Our aim was to develop a novel method to prepare nanoscale masks applicable for BPM. Samples were covered with a monolayer of silica nanospheres and treated with UV laser (λ=248 nm) pulses. The intensity distribution of the laser-illuminated area (1.5 cm x 5 cm) has been measured by means of a GaN photodiode and the energy densities required for the formation of the various morphologies were determined. The nanospheres of 300 nm of diameter exhibit hexagonal arrangement as self-assembled by means of the Langmuir-Blodgett (LB) method. The nanospheres act as individual lenses focusing the laser light underneath. This provides highly intense spots for nano-size processing of the sample. Depending on the beam parameters, an ordered array of hillocks, pits or holes of ~120 nm diameter can be molded /Figure 1. (a)/ which are suitable candidates for direct- or mask patterning. Sputter deposited amorphous AlO_x layers, as potential masks, were used for laser patterning. The structure and morphology of the patterned films were characterized by Atomic Force-, and Transmission Electron Microscopy. After the LB film had been removed, as expected from the computer simulation of energy distribution /Figure 1. (a)/, regular patterns of hillocks and holes could be observed depending on the laser intensity /Figure 1. (b), (c) and (d)/. The formation of the observed patterns can be revealed by the cross sectional TEM results shown in Figure 2. An overview in (a) shows hillocks, they seem to be arranged equidistantly (~250nm) on the AlO_x surface at the places of local maxima of the laser pulse. Figure 2. (b) illustrates a hillock. In the formed hillock crystallization event took place with crystallite sizes about 50 nm and the formation of separate, small bubbles indicating moderate energy impact. An increase of the local energy is suggested to ignite plasma and thereafter gas release blowing up large single bubbles as it is demonstrated in (c). Further increase of the local pulse energy causes the burst of the bubble forming a crater at the surface of the AlO_x layer as it can be seen in Figure 2. (d). This refers to a series of holes observed by AFM in Figure 1. (b). The above results show that by applying silica nanosphere LB films and carefully controlled UV laser pulses suitable masks can be fabricated for nanopatterning various thin films including high recording density magnetic media.

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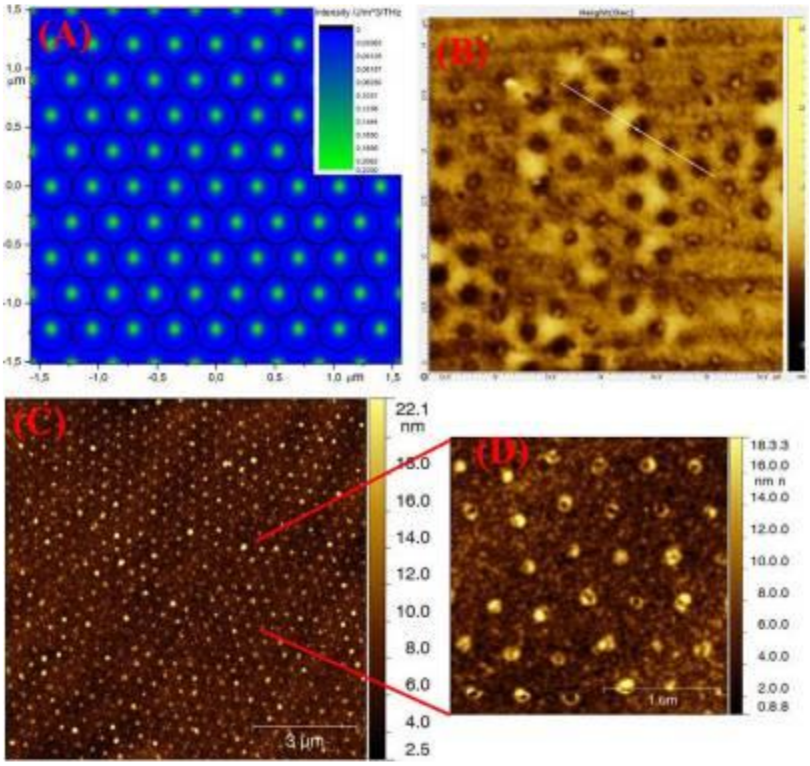

Figure 1. a) Simulation of the energy distribution of UV laser beam focused by self-assembled silica nanospheres; intensity rises from blue to green, b) AFM image of a fabricated hole pattern, c) and d) blown-up and blown-out nano-bubbles in a hexagonal array.

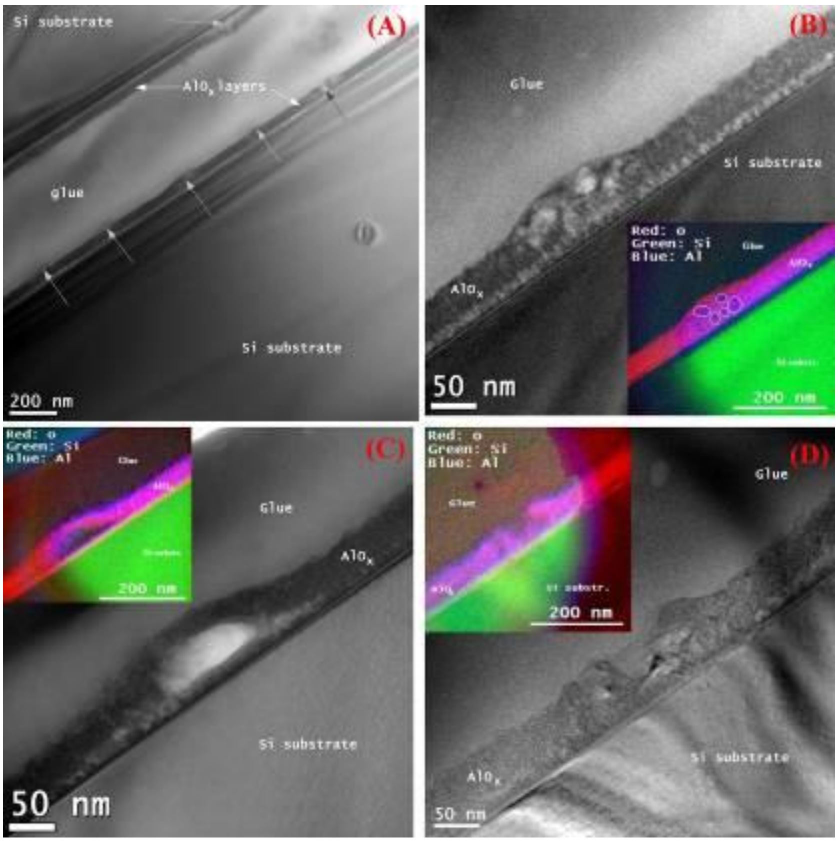

Figure 2. a) Cross-sectional TEM overview of a patterned AlO_x layer. The arrows indicate protruding features. b) A hillock is developed due to local recrystallization and formation of small discrete bubbles. c) Large single bubble due to increased laser energy. d) Cross-section of a crater resulted in a burst of bubble by the further increase of laser energy. The color insets are the EELS elemental maps depicting the distributions of O, Si and Al.