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Femtosecond laser-induced melting and shaping of indium nanostructures on silicon wafers

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We study the modification of indium semi-spherical nanostructures with radii of around 175nm on silicon wafers into linear microstructures more than 2μm long in the direction of polarization of laser pulses (1.56μm, 150fs, up to 7.5nJ and 30 000 laser pulses with 8MHz repetition rate). Scanning electron microscope (SEM) images of intact (top left) and irradiated nanostructures with ~13000 laser pulses with linear polarization. The energy of laser pulses is for the intact nanostructure. The scale bar is 250nm in all SEM images. We also investigate the illumination of indium nano-droplet on top of GaAs nanowires with an average height of 500nm. The grown nanostructures by vapor liquid solid technique are similar to the intact nanostructure that the base height is around 500nm above the substrate surface. The experimental results and a rudimentary analysis indicate that melting occurs from intense laser pulses. Illumination of a larger radius (r>175nm) semi-spherical indium nanostructures reveals that the number of protruded extensions depends on the diameter of the nanostructure. That is to say, only one line emerges from the smallest nanostructure, while two parallel lines came out of a larger nanostructure and so forth. It is shown that protruded lines period follows the period of high spatial frequency laser-induced periodic surface structures on a silicon substrate. In short, we demonstrate that the melting of the indium droplet followed by trapping in high spatial frequency laser-induced periodic surface structures on a silicon substrate cause nanostructure modification. The understanding of the modification process, melting and moving in the nano-grating structured field, pave the way to design nanostructures of arbitrary shapes at the sub-wavelength scale.

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