LASER-FOCUSED NANOFABRICATION WITH A CHROMIUM ATOMIC BEAM

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Atoms from an atomic beam, when they interact with a far-off-resonant laser standing-wave (SW), experience a spatially varying optical potential with a period of that of the SW. Depending on whether the laser frequency is tuned above or below an atomic resonance, the potential minima are either located in the nodes or anti-nodes of the light intensity, respectively. As the atoms pass through a potential minimum in the SW, they experience a focusing action similar to what light experiences in a lens. A laser SW can therefore be used to focus an atomic beam into an array of lines or dots. A substrate can then be placed into the modulated atomic beam and nanostructures can be grown. In this contribution we demonstrate two exciting applications of laser-manipulated nanofabrication with a chromium atomic beam: i) Fabrication of a Moiré pattern by beating of periodic nanostructures deposited at two atomic resonances and ii) Fabrication of a quasi-periodic structure by creating a quasi-periodic laser interference pattern. i) A laser-collimated chromium beam is deposited onto a substrate through a laser (SW) tuned above the atomic resonance at either of the two ^{52}Cr transitions $^7S_3 \rightarrow {}^7P_3^o$ at 427.600 nm or $^7S_3 \rightarrow {}^7P_4^o$ at 425.553 nm. In both these cases the resulting pattern on the surface consists of nanolines with a period of that of the SW. We extend the range of periods accessible to laser-focused atomic deposition by superimposing the structures grown at both these resonances. The resulting beating pattern exhibits a period of 44.46 ± 0.04 μm as determined with a polarizing optical microscope. This structure provides a link between nanoscopic and macroscopic worlds and could potentially become a calibration standard in length metrology. ii) A laser-collimated chromium atomic beam is deposited onto a substrate through a laser SW tuned 200 MHz above the ^{52}Cr transition $^7S_3 \rightarrow {}^7P_4^o$. In contrast to previous studies, where strictly periodic structures were grown, in this case the SW is created using five laser beams crossing at mutual angles of 72 degrees. The resulting light intensity pattern as well as the optical potential are quasi-periodic. We investigated the grown samples by means of atomic force microscopy. This study revealed a quasi-periodic chromium structure exhibiting a 10-fold symmetry. Extreme coherence of the laser-focused nanofabrication technique combined with the fact that this method can be integrated with molecular beam epitaxy offers exciting opportunities for fabrication of photonic quasicrystals.