# Laser Assisted Focused Ion Beam Processing

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Focused helium and neon ion beam processing from the gas field ion microscope has enhanced resolution for direct-write nanoscale synthesis relative to liquid gallium sources. The wide-spread use of focused $He^+$/$Ne^+$ beams as the next-generation nanofabrication tool-of-choice is currently limited by subsurface and peripheral damage induced during exposure by knock-on collisions and implantation. Here, we demonstrate the *in situ* mitigation of subsurface damage induced during $He^+$/$Ne^+$ exposures in silicon with an in situ infrared pulsed laser-assist process. The pulsed laser-assist photothermally heats the near surface region and decreases the implantation and defect (vacancy and interstitial) concentration by greater than 90 %. The laser-assisted exposure process was also shown to reduce peripheral defects graphene nano-channels patterned by patterned $He^+$ exposure; this makes laser assisted focused beam induced processing attractive for direct-write patterning of 2D materials. In this presentation we will overview the pulsed laser system and our previous laser assisted electron beam induced processing results. We will then compare sub-surface damage profiles for He+ and Ne+ in silicon with and without pulsed laser assist. The damage mitigation effects will be rationalized as a function of the photon/ion flux ratio, ion beam energy, and ion species. A simulation illustrating the pulsed laser heating and subsequent defect annihilation will also be reviewed. Finally we will preview our next generation pulsed laser tool design.

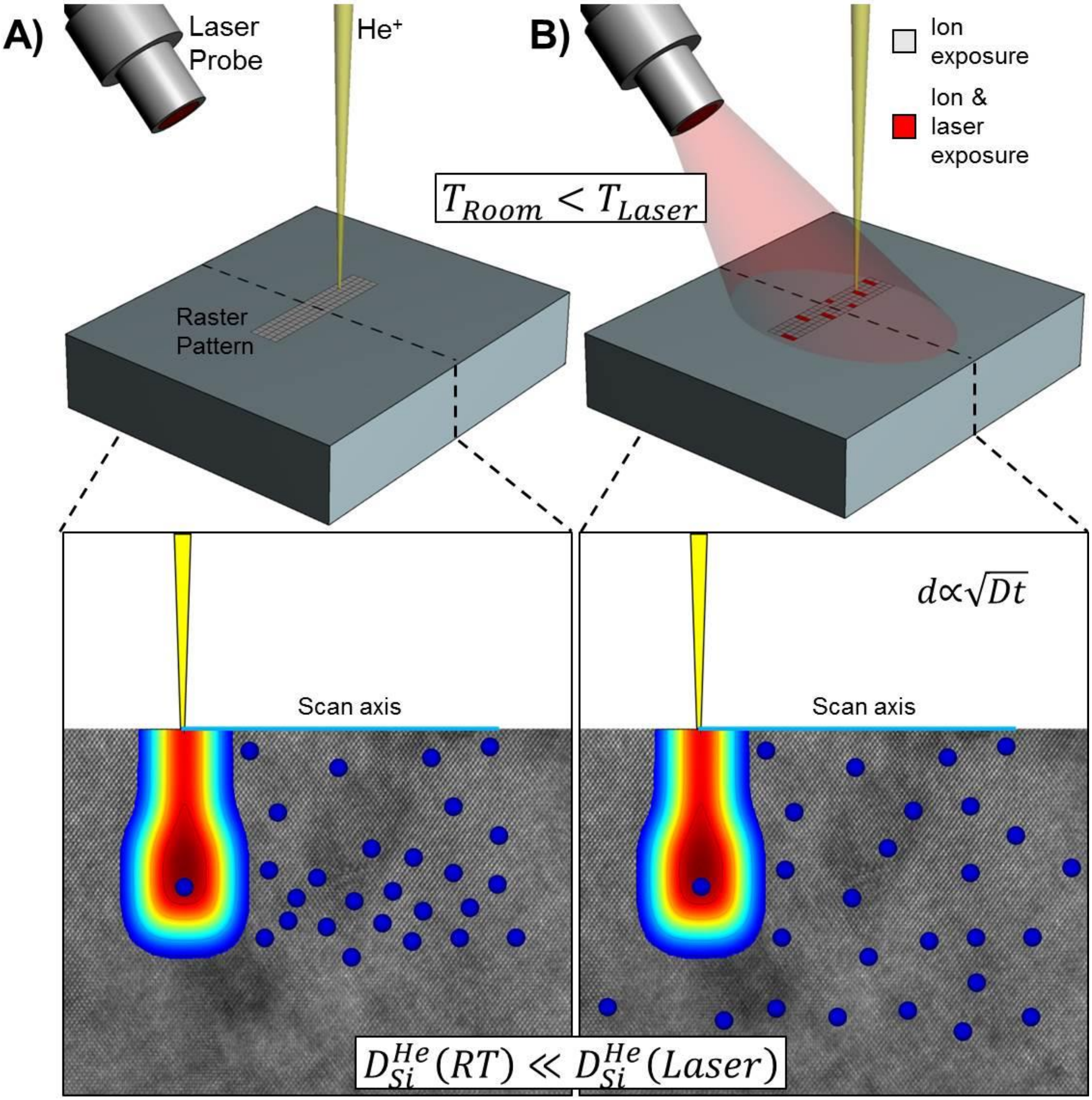


Figure 1. (top) Schematics illustrating a focused helium ion patterned exposure in silicon without (A) and with (B) a synchronized pulsed laser assist which photothermally heats the near surface region and enhances diffusion of the implanted He (blue circles) into and out of the beam interaction region and also enhances interstitial-vacancy annihilation.