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Top-down Direct Write Nanofabrication of Donors in Silicon and Defect Centers in Diamond

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We present on-going work using top-down direct write nanofabrication to create deterministic single atom devices for both research into quantum computation using single donors in silicon and diamond nano-photonic devices using SiV defect centers. This work is carried out using Sandia's nanoImplanter (nI). This is a 100 kV focused ion beam system setup for both mass resolution using an ExB filter and single ion implantation using fast blanking and chopping. We combine this with a lithography pattern generator for high resolution nanofabrication. Additionally, we have demonstrated the single ion detection on both Silicon and Diamond substrates using ion beam induced charge (IBIC) collection. The combination of single resolution direct write fabrication and integrated single ion detection allows for the fabrication of single atom devices.

The creation of single donor based quantum computing goes back to Kane [1]. We have implemented a fabrication pathway that combines focused ion implantation with *in-situ* counted ion detection. We have integrated avalanche photodiodes with quantum transport nanostructures and demonstrated low temperature transport in counted samples [2]. We have detected Sb ions down to 20 keV generating at most ~1200 e-h pairs/ion with a SNR of 2. This focused ion beam approach allows for a positioning accuracy of <35 nm, defined by the beam spot size.

Color centers in diamond have been used for a range of applications from metrology to single photon sources for secure quantum communication [3]. Here we will discuss the ability to deterministically implant ions into photonic nanostructures with high spatial resolution. Separately, we have demonstrated the ability to detect single ion implants using an *in-situ* diamond detector with a SNR approaching 10 for detection of single 200 keV Si ions.

In sum, direct write nanofabrication has been demonstrated for single atom devices in both silicon and diamond substrates using a top-down ion implantation approach.

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