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Title:

SiV yield optimization via counted ion implantation

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Abstract (2334/3000 characters):

The status of color center yield is a critical limitation for their integration with microfabricated devices and realizing architectures to couple individual centers. Although great progress has been made with deterministic spatial formation both by focused ion beam implantation and nanometer scale masking of broad beams, a process for the reliable activation of implanted centers has not been developed. A primary factor impeding the development of such a process is the inherent uncertainty in the number of implanted ions due to the Poisson statistics of ion implantation. As well, yields <10% are typical for SiV center formation by ion implantation. These two factors limit progress in improving color center yield. We propose a novel path for improving color center yield.

We have adapted the technique of in-situ ionization detection used for low energy counted ion implantation into Silicon and applied it to the diamond substrate. The in-situ diamond detector, we have developed, allows for the counting of single ions with an SNR approaching 10 for a 200 keV Silicon implant. This SNR results in an expected ion counting error rate of less than 1%, thereby removing a known source of Poisson statistics. We will present yield measurements of SiV center formation via counted implantation of Silicon atoms from a focused ion beam system with a 20 nm spot size. Additionally, we will test the feasibility of counted ion implantation as a platform for yield optimization by measuring the change in yield when additional vacancies are introduced local to a Silicon implantation by the subsequent implantation of light ions. We anticipate that the technique of counted implantation will serve as a platform to develop a more certain understanding of how color center yield depends on factors such as the local number of vacancies, anneal parameters, and surface termination.

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Outline:

I. Intro/Motivation –
  a. SiV yield is a critical limitation for advancing the science and realizing devices
  b. Spatially deterministic implantation is there, but a process for reliable activation is not.
  c. Typical yields are around 10% and subject to Poisson statistics.
  d. Understood factors determining yield are the number of vacancies, charge state control, and the anneal parameters.
  e.
  f. A fundamental limitation for activation is the Poisson statistics of the ion beam.
  g. Have developed a technique for counted ion implantation in diamond
  h. This detection scheme will allow us to implant a fixed number of ions into a diamond substrate.
  i. This detection scheme will allow us to implant arrays of a fixed number of Si atoms per spot.
  j. The array can serve as a platform for investigating how to optimize the paramaters for color center formation yield such as more vacancies, charge state control, anneal parameters

II. Background - Results of efforts to date
  a. Yield is subject to Poisson statistics
  b. The yield is low on the order of 10% and limited by the number of vacancies

III. Methods - counted implantation
  a. Single ion detection to ‘count’ in ions
  b. Removes a source of Poisson statistics
  c. Serves as a basis to develop an understanding of the parameters for single SiV yield.
  d. Will use this platform to test the vacancy limited hypothesis – yield improvement via registered subsequent implantation