CHAPTER-X

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This thesis deals with the generation of diffraction-free nanoscale optical beam and to use it to record and read digital data in 2-D and 3-D optical memory disk systems. The key element of the proposed system is that the diffraction free Bessel (DFB) beams can propagate long distances without the diffractive spreading that is normally present in Gaussian beams. This approach can achieve x,y resolution of sub wavelength, and can also have roughly millimeter depth of field along the propagation (z) direction. This depth of field allows us to overcome the z resolution limitation of conventional dynamic focusing systems. This is achieved by totally eliminating the requirement for precise z adjustment of the read/write focused beams in conventional systems, which is a major factor limiting the speed as well as the resolution (~1μm) of these systems. It is well known that a light spot of sub wavelength will diverge in all direction. In this work, A method is presented for generating near-field optical virtual probe, which propagates without divergence in free space. This is achieved by means of immersing the propagating Bessel beam in to an Axicon of high refractive index (SIAX) and extending it to the evanescent regime. We have also proposed a method for generating sub wavelength (0.44λ) longitudinally polarized beam, which propagates without divergence over lengths of about 2λ in free space. This is achieved by means of high NA lens axicon that utilizes spherical aberration to
duplicate the performance of an axicon and to create an extended focal line. It is also analyzed numerically that the proposed system generates Diffraction free beam with nano scale resolution having a constant intensity and central lobe size in the desired range of focal segment. The intensity ratio of side lobe is found to be much smaller than the central lobe and hence the recording and reading errors due to side lobe can be effectively avoided in this system. To generate Nanoscale DFB annular-aperture diffractive axicons for Gaussian beam illumination is designed. Both the stationary phase method and numerical calculation are applied to solve the diffraction integral. It is observed that the apodization inserted into the axicon eliminates the intensity oscillation along the focal segment, so that the non-uniformity of the on-axis intensity distribution along the focal segment can be greatly reduced. An Axicon, which is a combined symmetrically Cubic lens phase plate with a perfect lens, is also analysed to generate nanoscale resolution beam with extended depth of focus for high density optical recording. Both the stationary phase method and numerical calculation are applied to solve the diffraction integral describing the characteristics of the focal segment. The nano scale resolution of the proposed axicon system increases the recording area density over the fiber ended lens system (spot resolution of ~1μm). The large Depth of Focus (DOF) of axicon lens avoids the mechanical damage of the lens surface due to its friction with the spinning disk and helps to integrate other components easily with the system and more over this system totally eliminates the requirement for precise z adjustment of the read/write focused beams in
conventional systems, which is a major factor limiting the speed as well as the resolution (\(~1\ \mu m\) of these systems. A comparative study on the focal performance of the fiber ended hemispherical microlens and fiber ended Axicon is done. The fiber ended hemispherical lens is optimized for better performance and a basic design of the DFB- optical recording system is proposed. It is observed that the fiber ended lens system can have maximum NA around 0.27. This limits the recording density and demands the integrated SIL and sub micron aperture to improve the mechanical fragility and to increase the NA but the model suggested to generate DFB using fiber ended axicon can generate DFB, with a DOF around a millimeter with a sub wavelength lateral resolution.