The basic objective of this research was to develop a process for fabrication of photomasks for SAW sensor application. SAW devices can be used for a large variety of sensors namely, physical, chemical and biological. In this particular research work, the process for fabricating photomasks using 413 nm wavelength LASER Pattern generator was developed. Test masks were written and processed using developed process and performance of process was analysed. A SAW resonator test mask was also written. Finally, a SAW resonator mask (CD 1.69 micron and operating frequency 500 MHz) was written and processed using developed process. The critical dimensions in developed and etched mask were measured using a SEM. A SAW resonator was fabricated and its performance was observed. Finally, a SAW resonator based Sarin (DMMP) sensor was fabricated and its performance was observed. Thus, the process developed was validated by fabricating SAW resonator mask, resonator and SAW Sarin (DMMP) sensor.

The work started with an extensive study of mask fabrication technology and lithography. The historical perspective of mask fabrication using optical method (LASER Pattern Generator) were studied. The process was decided to be developed for LASER Pattern generator ($\lambda=413$ nm). A SAW resonator, having CD as 1.69 micron and operating frequency of 500 MHz was the targeted device as SAW sensor for detection of sarin (DMMP).

The experiments were conducted pre coated and pre baked chrome blanks. The developer used was PPD-455, the etchant used was CEP-200, and Stripper used was PRS-100. For cleaning, Piranha solution (SPM-Sulphuric acid and Hydrogen Peroxide mixture) was used. The different types of test structures for characterizing processes were designed in dxf and gdsii formats. Standard test pattern for optimizing writing process was also made in dxf and gdsi. The design data was tested and verified prior to mask writing. The design data for resonator mask was also obtained and a test mask data was prepared from it. The data was verified and converted before exposure and transferred to User PC, for exposure.

For developing mask fabrication process, writing process was first developed. For this purpose, Energy and defocus values were found out after systematic experimentation for both Bright field (BF) and dark field (DF) masks.
After establishing writing process, development, descuming, etching and stripping processes were developed. To find out the right development time, exposed plates were developed for different times, and thickness of remaining photoresist was measured. It was observed that all exposed photoresist dissolved in 60 s. For descuming, experiments were conducted in Plasma Asher using oxygen and oxygen + Helium gas. A process time for descuming was established as one minute at 100 W power and 100-120 ml/min Oxygen flow. The etching time was found out by measuring thickness of chrome after pre-determined times after putting developed plates in the etchant solution. The etching time was observed as 60 s. For finding stripping time, resist coated mask plates were put in stripper solution and thickness of remaining resist was measured after pre-determined time. It was observed that all resist dissolved in 120 seconds. The effect of development time and etch time on CD was also observed in wet process. A parallel process for Dry processing of masks was developed using Reactive Ion Etcher (Plassys MG 350). It is a parallel plate reactor. The processes develop were descuming, chrome etching and stripping.

Test masks were exposed and processed using developed processes. Line widths upto 0.7 micron and via upto 1.5 micron could be fabricated. There was no difference in line width and space patterns in SAW structures, indicating negligible or no proximity effect. SAW structures upto 1.5 micron could be easily fabricated. No difference was observed in isolated and grouped lines and via in bright field and dark field masks. The Vias below 3 micron size became circles. A SAW test mask for SAW resonator was also written and processed. The design CD was 1.69 micron. Microscope measurements showed values between 1.6 and 1.8 micron. SEM measurements were found between 1.682 µm and 1.720 µm, a deviation of 8 nm to 30 nm across the structure, which is within tolerance limit of 5% or 0.1 µm, validating the process.

Finally, a SAW resonator mask was written and processed using developed process. This mask was used for fabricating a SAW resonator operating at 500 MHz. The resonator demonstrated resonance at 505.7 MHz, validating process. A SAW Resonator based Sarin (DMMP) sensor was finally fabricated and its performance was evaluated. A frequency shift of 700 Hz was obtained at 3 ppm, indicating sensitivity of 233 Hz/ppm. The results were found better than reported results for resonator sensor.
The objective of the research/study was, thus, fully achieved as the developed processes, which include process for pattern writing using LPG system and wet chemical & dry plasma processes for development and etching, met the requirements of very low design tolerance photomasks fabrication. The developed process was fully validated by display of perfect functioning of the fabricated SAW resonator and Sarin (DMMP) sensor fabricated using the developed process.

**Scope for Future Work:**

In order to fully exploit the potential of LASER pattern generator and wet and dry processes for mask fabrication, following work needs to be done.

- Modelling of ‘design tailoring’ and ‘design compensation’ in sub micron structure photomasks.
- Study of developed process versatility by fabrication of photomasks with device structures 0.5<CD<1\(\mu\)m.
- Study of Chrome loading effects in dry etching using RIE and ICP-RIE.