Immersion technique was first introduced by Carl Zeiss in 1880s to increase the power of the optical microscope [4]. Currently, the ArF (Argon Fluoride) immersion lithography process is in practice which uses an ArF excimer laser as its light source and water as the liquid medium between the laser and wafer. The refractive index of ArF excimer laser beam is 1.44 with water.

The angle of light exposure on wafer is smaller than air which makes it possible to increase the numerical aperture over 1 and to improve the resolution.

Several methods like Phase Shifting and Optical Proximity Correction (OPC) are introduced to make light produce high resolution images.

Introduction
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- The refractive index of ArF excimer laser beam is 1.44 with water.

Fig 1. Immersion Lithography [5]

Process and Methods
**DOUBLE PATTERNING:**
Double Patterning Lithography has been introduced as continuation in the advancement of fabrication as per Moore’s law. Double patterning will allow the fabrication of the 22nm node and beyond [2].

**Double Patterning Lithography Techniques:**
1. Litho-etch litho-etch (LELE)
2. Litho-freeze litho-etch (LFLE)
3. Self-aligned double patterning (SADP)

**HYPER-NA IMMERSION LITHOGRAPHY:**
Hyper-Numerical Aperture Immersion Lithography is like projection lithography which provides the capability to achieve much higher resolution. The mechanism behind reducing the minimum feature size is directly proportional to the numerical aperture of the imaging equipment used [2].

Fig 2. LELE Process [2]
Fig 3. LFLE Process [2]
Fig 4. SADP Process [2]

**Fig 5. Overall setup of Immersion Lithography [2]**

**Fig 6. Shadow created by nano bubble [1]**

Challenges and Defects
The first challenge is leaching which degrades the resist performance and contaminates the water. The contaminated water can further contaminate the lens and water can also permeate into resist film [4].

Particles can generate several types of defects:
- During exposure, particles can block or scatter light, creating extra pattern and these particles can be in contact with the wafer surface [3].
- After exposure, the remaining particles can act as a developer block which also creates extra pattern [3].

**Problems with water**
**Water Purification:**
- Contaminants in the water is completely dominated by absorption rates.
- Biggest source of contamination is gas bubbles which can create shadows in the light.
- Special handling of water is required to prevent the formation of bubbles.
- Water should be constantly monitored to ensure the purity.

**Water/Lens interface:**
- The performance and contaminates the water. The contaminated water can further contaminate the lens and water can also permeate into resist film [4].
- The interface between the lens and the wafer’s surface, thus allowing small feature sizes.

**Fig 7. Water/Lens interface:**

**Fig 8. Water/Lens interface:**

**Fig 9. Water/Lens interface:**

Conclusion and Future Scope
- Even though Immersion lithography come with several advantages like improvement in resolution and depth of focus, it also suffers from many defect and manufacture related challenges.
- Lithography at 193 nm has been enabled and extended by Phase Shifting photomasks and Optical Proximity Correction (OPC) which makes light produce high resolution images.
- Immersion lithography is a stepping stone to EUV lithography. Due to difficulties in finding the liquids, its use is limited beyond 193nm [1].

References
1. Immersion Lithography - Stretching the limits of Deep UV lithography, John Culver March 13, 2006