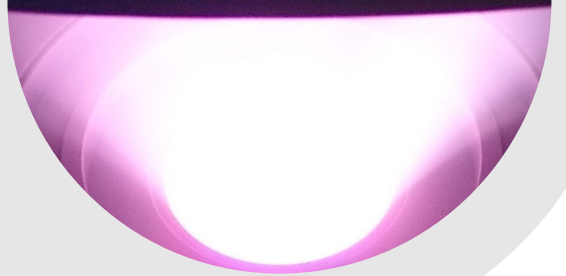


ECRプラズマ成膜法の原理と特長

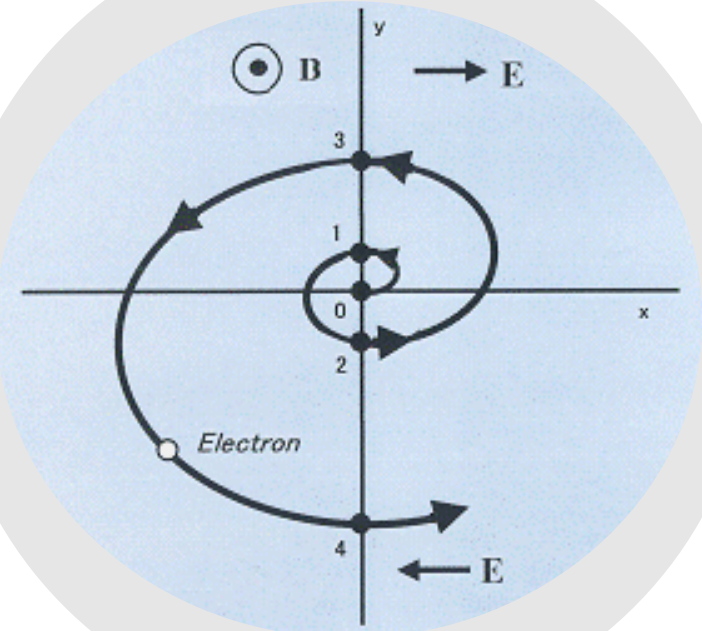
Principles and Features of ECR Plasma Deposition

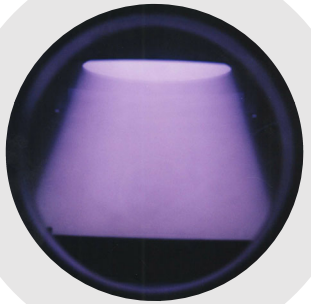
ECRプラズマ生成の原理

Principle of ECR Plasma Generation

- 磁界強度87.5mT(ﾃｽﾗ)の磁力線の周りを回転する電子は、2.45GHzの交流電界で共振し(Electron Cyclotron Resonance, 電子サイクロトロン共鳴)、エネルギーを受け取って高速回転します。このため、放電が難しい低圧でもガス分子との衝突が起こり、効率よくプラズマが発生します。

  - Electron that is orbited around magnetic forth line at 87.5 mT is resonated with an AC electric field of 2.45 GHz (Electron Cyclotron Resonance), and are rotated at high speed by received energy. Therefore the plasma is efficiently generated as the electorn can collides with gas molecules even low pressure.



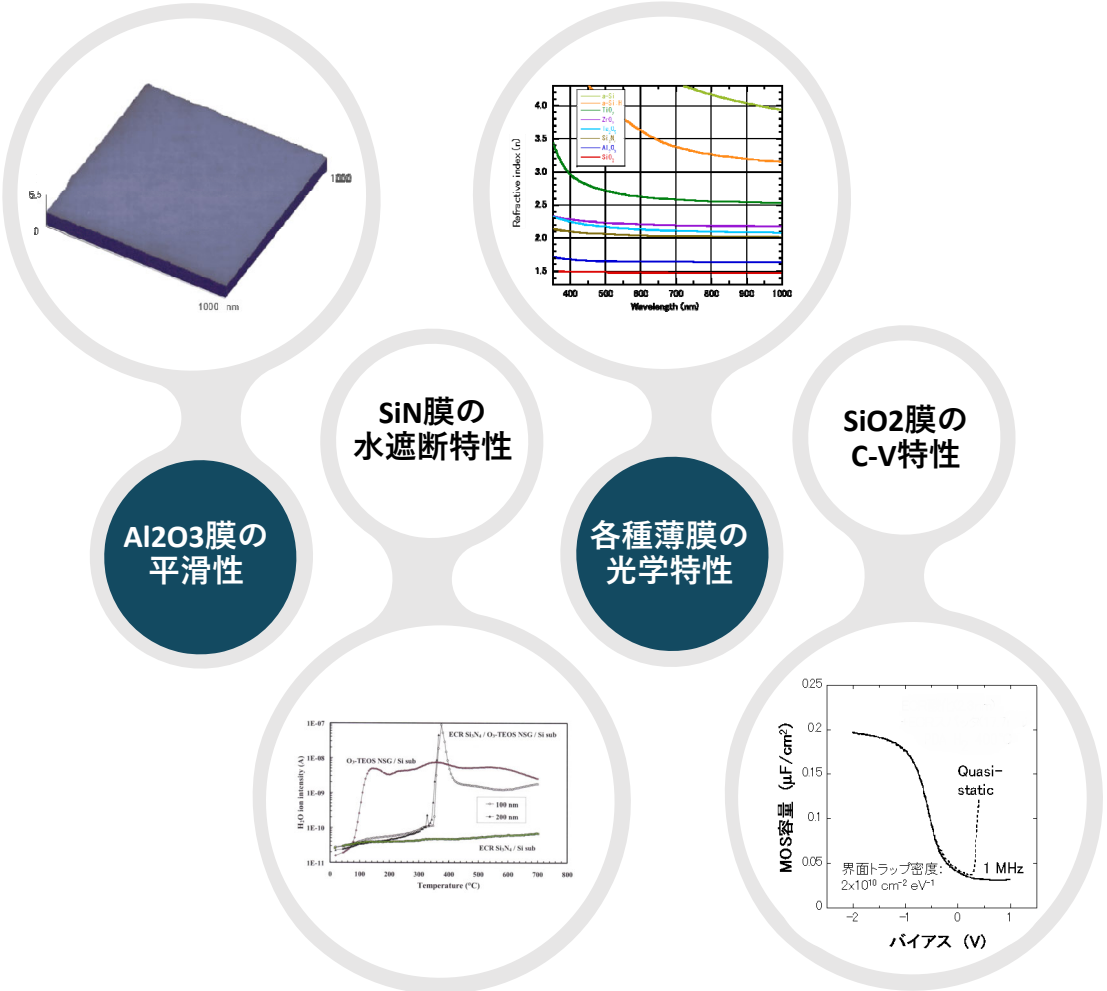


ECRプラズマの特徴

Features of ECR Plasma

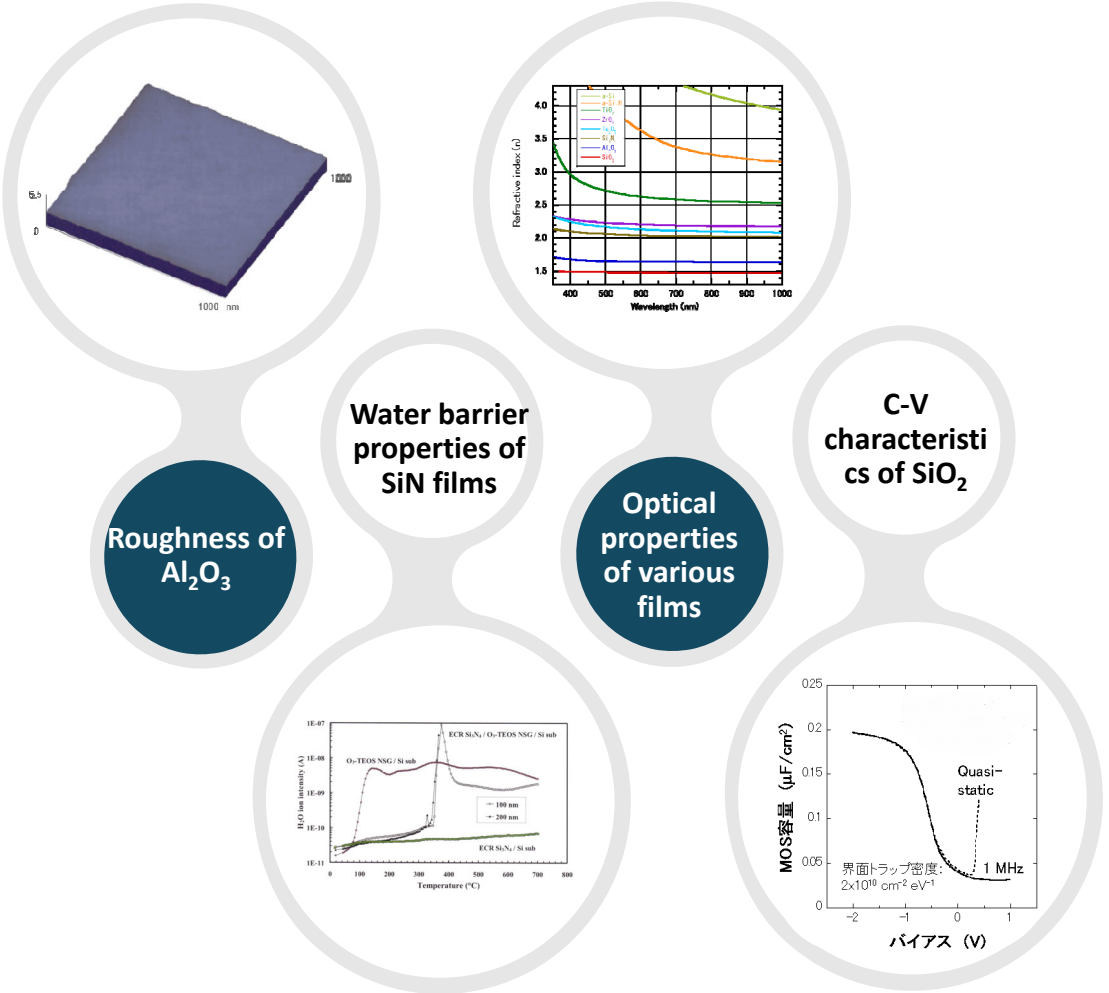
- 無電極、低ガス圧 (0.01-0.2Pa)、高密度 (10^{12} cm^{-3})
  - Electrodeless, Low pressure (0.1 – 0.2 Pa), High density (10^{12} cm^{-3})
- 基板表面への低エネルギー(10-30eV)大電流のイオン照射効果
  - Ion irradiation effect with low energy (10 – 30 eV) and high current to substrate surfaces

ECR薄膜の物性



- 平滑性： 原子１個レベルの僅かな凹凸
- 硬さ： SiN膜、カーボン膜はダイヤモンド並みの硬さ
- 緻密さ： SiN膜の弗酸耐性はPECVD膜の10倍。水分や水素に対しても高いバリア性
- 光学特性： 高精度な屈折率制御。高い光透過性（SiO2,SiN,Al2O3,AlN,Ta2O5,ZrO2など）
- 不純物フリー： 高純度ターゲットとガスを原料とし、反応生成物（H, F, Clなど）無く、高純度
- 高配向性： AlN膜、MgO膜などの高い配向性。低抵抗TiN膜、α-Ta膜
- 被覆性： 低ガス圧、高イオン化率、傾斜回転成膜により、一般のスパッタよりも段差被覆性が高い
- 高耐圧： バルク並みの高耐圧絶縁膜。SiO2, Al2O3膜などは10MV/cm (1000℃熱酸化膜並み)
- 低損傷： MOSキャパシタの界面準位、界面電荷が小さい
- 高誘電率： メタルモード成膜により界面酸化膜の形成を抑制。

Physical properties of ECR films



- Roughness: Tiny roughness at the single-atom level
- Hardness: SiN films and carbon films have hardnesses similar to those of diamond
- Density: The hydrofluoric acid resistance of SiN is ten times that of PECVD film. It also has a high barrier ability with respect to moisture and hydrogen.
- Optical characteristics： Highly precise refractive index control, high optical permeability (SiO2, SiN, AI2O2, AIN, Ta2O2, ZrO2, etc.)
- Impurity-free: High-purity target and gas used as ingredients to achieve high levels of purity with no reaction products (H, F, CI, etc.)
- High orientation: Orientation of AIN films, MgO films, etc. Low-resistivity TiN films and α-Ta films
- Coverage: Coverage of bumps is much higher than with general sputtering, by formation of inclined rotation film at low gas pressure and high ionization rate
- High voltages: High-voltage insulation film similar to bulk. 10 MV/cm for SiO_2 and Al_2O_3 films (similar to 1000° C thermal oxidation film)
- Low damage: Low Interface state and charges of MOS capacitor
- High permittivity： Formation of oxide films of interface layer inhibited by metal-mode deposition