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**Si_Z O_X N_Y BY
INDUCTIVE-COUPLED-PLASMA
PLASMA-ENHANCED CHEMICAL VAPOR
DEPOSITION FOR MULTI-LAYER OPTICAL THIN
FILMS**

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Introduction

Low-temperature-grown thin films are interesting for numerous applications in micro-electronics / photonics. The ability to grow materials whose refractive index can span a wide range of values facilitates the fabrication of optical multilayer stacks and, by proxy, of opto-electronic devices.

Here, we establish the deposition conditions of SiON thin films by Inductively-Coupled-Plasma Plasma Enhanced Chemical Vapor Deposition (ICP-PECVD) at low temperature (100°C) et demonstrate their use to create anti-reflective and mirror optical coatings.

Materials & processes

Silica (SiO₂), silicon nitride (Si₃N₄) and amorphous silicon (a-Si) are conventionally used materials for micro-electronics and photonics.

Here, we study two types of alloys

- SiO₂ / Si₃N₄
- Si₃N₄ / a-Si

The SiO₂ / Si₃N₄ compounds are created by variation of the N₂O gas flux in the SiH₄/N₂O/N₂ gas mixture.

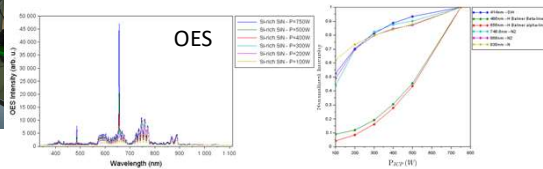
The Si₃N₄ / aSi materials are obtained by modification of the plasma RF power for fixed SiH₄/N₂ gas injection.

Instrumented equipment

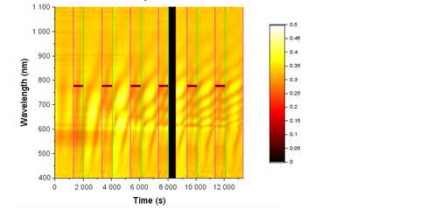


In-situ real-time characterisation tools:

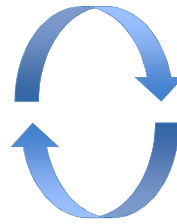
- Optical Emission Spectroscopy
- Reflectometry



Reflectivity – 1550nm DBR

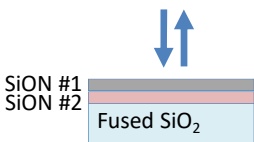


Optical thin-film coatings



Material characterisation

Anti-Reflective coating



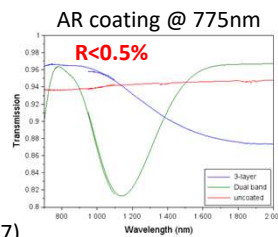
Design criteria

1. R=0%
2. Wide Bandwidth

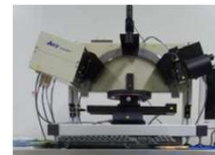
(1) => $n_2 \sim (n_{\text{subs}}/n_{\text{air}})^{0.5} \cdot n_1$

(2) => low dispersion

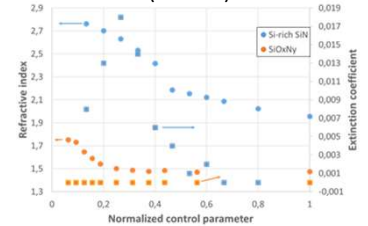
=> SiON #1 = SiO₂ (& $n_2 \sim 1.67$)



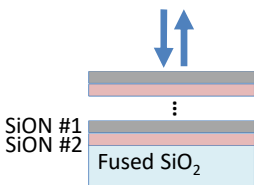
Ellipsometry



n(775nm)



Mirror coating



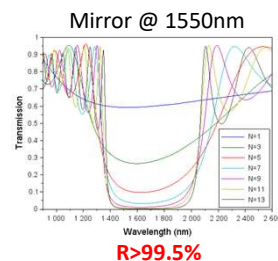
Design criteria

1. R>99%
2. Wide Bandwidth

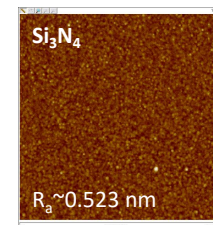
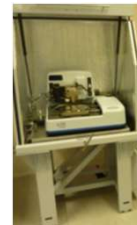
(1) & (2) => high n_1/n_2

=> SiON #2 = SiO₂ &

SiON #1 = high-Si Si-SiN



Atomic Force Microscope



| Alloys | R _a (nm) |
|---|---------------------|
| SiO ₂ / Si ₃ N ₄ | 0.68-1.08 |
| Si ₃ N ₄ / aSi | 0.41-0.51 |

Conclusions

- ✓ Found the conditions to deposit mixed alloys between SiO₂ / Si₃N₄ and Si₃N₄ / a-Si
- ✓ Use real-time in-situ monitoring tools to gain insight into/monitor the depositions
- ✓ SiON layers with compositionally-adjustable refractive index between 1.48 to 2.78+i0.007 @ 775nm with roughness < 1nm
- ✓ Demonstrated multilayer coatings

