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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

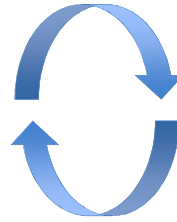
Silica (SiO<sub>2</sub>), silicon nitride (Si<sub>3</sub>N<sub>4</sub>) and amorphous silicon (a-Si) are conventionally used materials for micro-electronics and photonics.

Here, we study two types of alloys

- SiO<sub>2</sub> / Si<sub>3</sub>N<sub>4</sub>
- Si<sub>3</sub>N<sub>4</sub> / a-Si

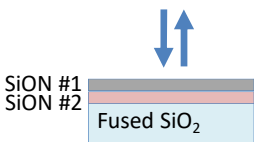
The SiO<sub>2</sub> / Si<sub>3</sub>N<sub>4</sub> compounds are created by variation of the N<sub>2</sub>O gas flux in the SiH<sub>4</sub>/N<sub>2</sub>O/N<sub>2</sub> gas mixture.

The Si<sub>3</sub>N<sub>4</sub> / aSi materials are obtained by modification of the plasma RF power for fixed SiH<sub>4</sub>/N<sub>2</sub> gas injection.



## Optical thin-film coatings

### Anti-Reflective coating



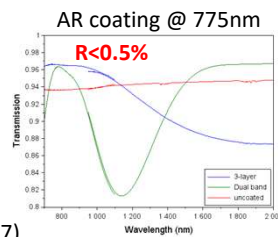
#### Design criteria

1. R=0%
2. Wide Bandwidth

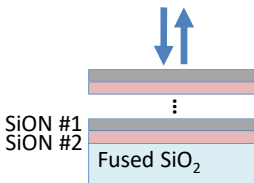
(1) =>  $n_2 \sim (n_{\text{subs}}/n_{\text{air}})^{0.5} \cdot n_1$

(2) => low dispersion

=> SiON #1 = SiO<sub>2</sub> (&  $n_2 \sim 1.67$ )



### Mirror coating

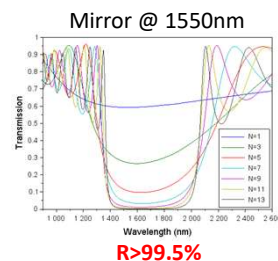


#### Design criteria

1. R>99%
2. Wide Bandwidth

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

=> SiON #2 = SiO<sub>2</sub> &  
SiON #1 = high-Si Si-SiN



## Conclusions

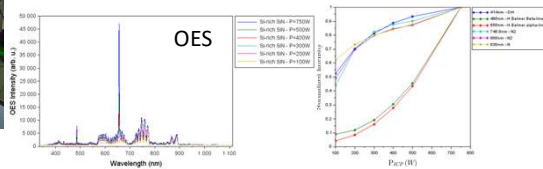
- ✓ Found the conditions to deposit mixed alloys between SiO<sub>2</sub>/Si<sub>3</sub>N<sub>4</sub> and Si<sub>3</sub>N<sub>4</sub>/a-Si
- ✓ Use real-time in-situ monitoring tools to gain insight into/monitor the depositions
- ✓ SiON layers with compositionally-adjustable refractive index between 1.48 to 2.78+i0.007 @ 775nm with roughness < 1nm
- ✓ Demonstrated multilayer coatings

## Instrumented equipment

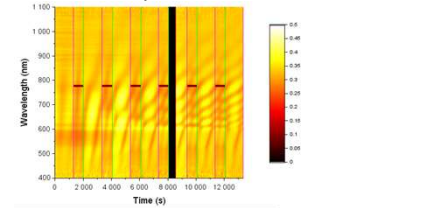


In-situ real-time characterisation tools:

- Optical Emission Spectroscopy
- Reflectometry



### Reflectivity – 1550nm DBR

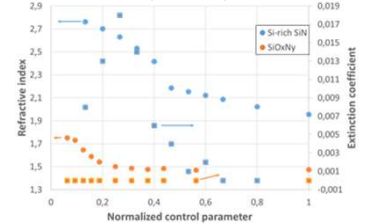


## Material characterisation

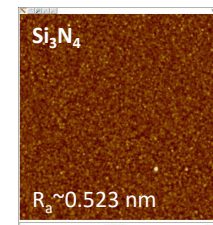
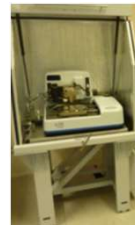
### Ellipsometry



### n(775nm)



### Atomic Force Microscope



Alloys	R <sub>a</sub> (nm)
SiO <sub>2</sub> / Si <sub>3</sub> N <sub>4</sub>	0.68-1.08
Si <sub>3</sub> N <sub>4</sub> / aSi	0.41-0.51