Strategies for high-quality nitride and oxide stacks by plasma ALD

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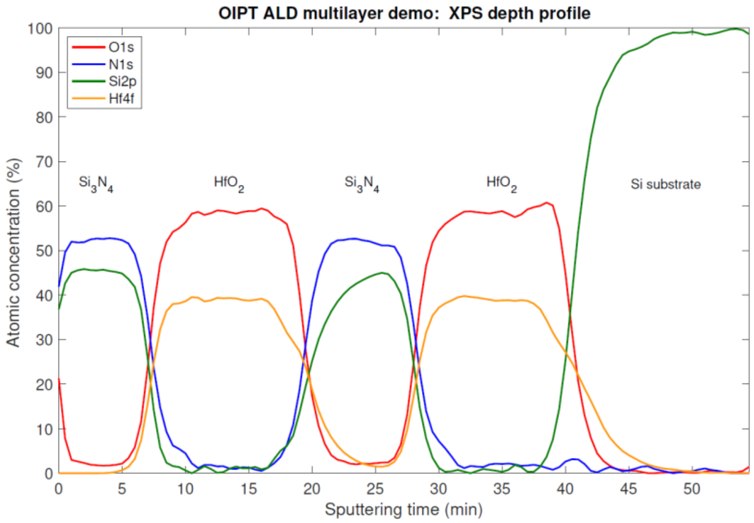
Many applications in industry require the deposition of nitrides and oxides with high purity and with high-quality interfaces. The focus of most atomic layer deposition (ALD) studies is on the deposition of a single layer in a dedicated deposition chamber. This contribution highlights a set of strategies for high-quality nitride and oxide stacks deposited by ALD in a single run in a single chamber. As an example, an HfO_2/SiN_x multilayer is demonstrated with <5% oxygen in the nitride.

Low oxygen content is a challenge for nitride deposition, especially when lines and chambers might contain oxygen and water traces from a previous deposition. To demonstrate a high-quality oxide and nitride stack, HfO_2 using TDMAHf and O_2 plasma and SiN_x using BTBAS and N_2 plasma are employed. The depositions are carried out in a FlexAL system in a single run and to get the best SiN_x the residence time was minimized by a combination of turbo pumping, chamber heating and pressure and flow control.[1] For other ALD nitride processes substrate biasing could be employed to lower oxygen content, but in the case of SiN_x this is less effective.[2] When switching from oxide to nitride deposition, the following strategies are employed:

- Strong purging and pumping of any gas lines that could contain oxygen or oxygen byproducts.
- TDMAHf precursor pulses to scavenge possible oxygen by-products.
- Plasma treatment of the chamber and wafer surface.

After the subsequent deposition of the nitride the surface is exposed to a plasma post-treatment to further densify the material and protect it against oxidation. Using this strategy an alternating stack of HfO_2 and SiN_x was deposited with individual layer thicknesses of 20 nm. XPS depth analysis indicated that even with this relatively fast switching, oxygen content levels <5% were obtained for SiN_x (XPS analysis by Dr. Shihong Xu, nanoFAB Centre, University of Alberta). This example and general strategies for such oxide and nitride stacks will be presented.

1. Knoops et al., *Appl. Phys. Lett.* **107**, 014102 (2015)
2. Faraz et al., *Plasma Sources Sci. Technol.* **28**, 024002 (2019)



XPS depth profile of plasma ALD stack. Even though oxygen and nitrogen plasmas are used, both oxide and nitride have low N and O content respectively. XPS analysis by Dr. Shihong Xu, nanoFAB Centre, University of Alberta, Edmonton, Alberta, Canada