



AN 383

High-k Film Analysis by RBS and NRA

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Discussion

Thin high-k films like refractory metal oxides HfO_x and ZrO_x , are expected to play an important role as gate oxide materials in future generations of semiconductor manufacturing. Light elements, such as C, N and O are normally present in these films at percent level concentrations. Their presence has significant impact on the performance of high-k films and it is crucial to accurately measure these light elements. With Rutherford Backscattering Spectroscopy (RBS) it is possible to obtain the oxygen to metal ratio, but RBS has limited detection limits for light number elements (~ 6 atom-%). Charles Evans & Associates has implemented Nuclear Reaction Analysis (NRA) techniques to improve C, N and O detection limits down to a fraction of an atom percent. The combination of RBS and NRA can now accurately measure the oxygen to metal ratios and low content C and N in thin high-k films.

Figure 1 shows a RBS spectrum of 26nm of HfO_x on Si. From this RBS spectrum, the ratio of O/Hf was determined but it was hard to discern the presence of C and N in this film. Figure 2 shows an NRA spectrum obtained with 1.0MeV deuterons. It is clear in this spectrum that this film has some level of carbon impurity. The composition of this film was determined to be $\text{Hf}_{0.3}2\text{O}_{0.64}\text{C}_{0.036}\text{Zr}_{0.004}$.

In conclusion, the combination of RBS/NRA can be used to measure $\text{MC}_x\text{N}_y\text{O}_z$ films (M=Hf, Zr, Ta, Ti, Ru, W, Y, etc) with detection limits of less than 1 atom % for C, N and O.

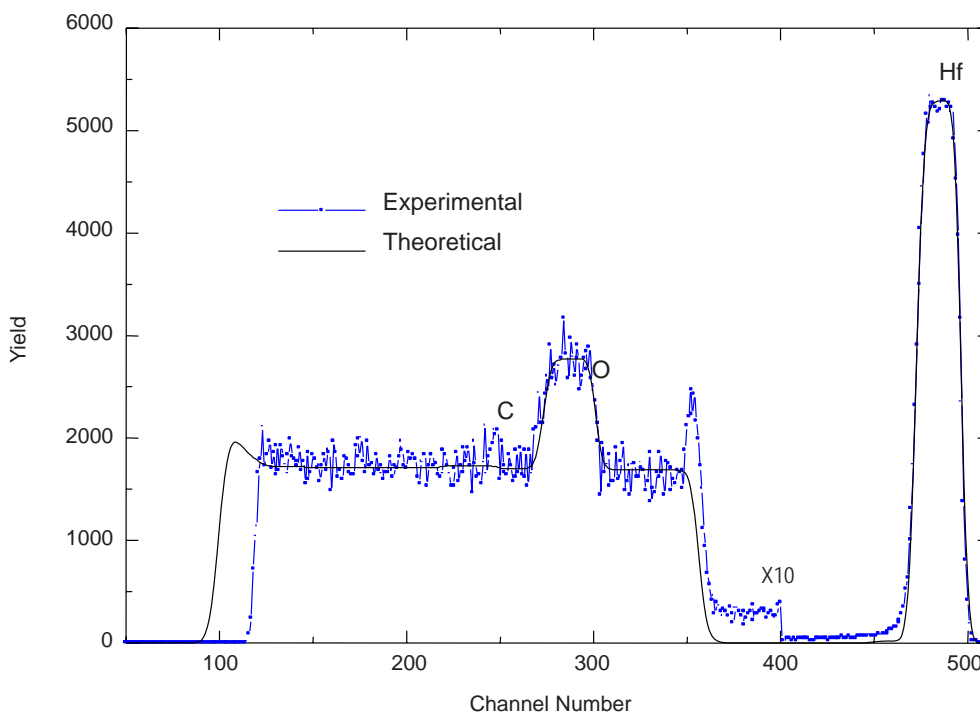


Figure 1. RBS spectrum of 26nm HfO_x

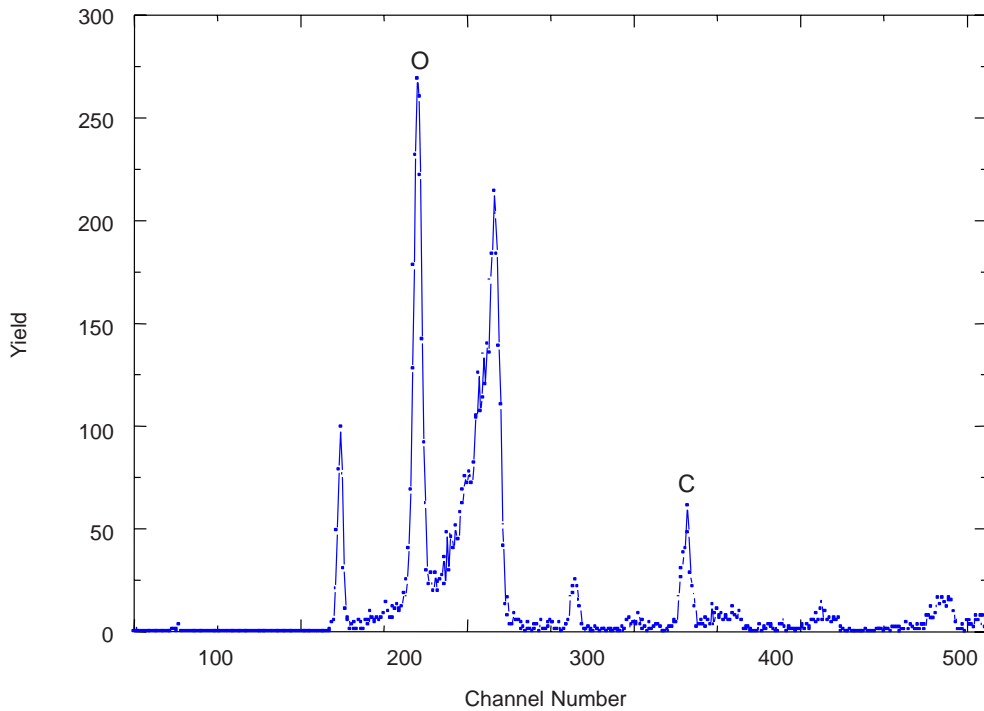


Figure 2. NRA spectrum of 26nm HfO_x

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