



AN 381

Nuclear Reaction Analysis (NRA) for Li, B, C, N, O and F

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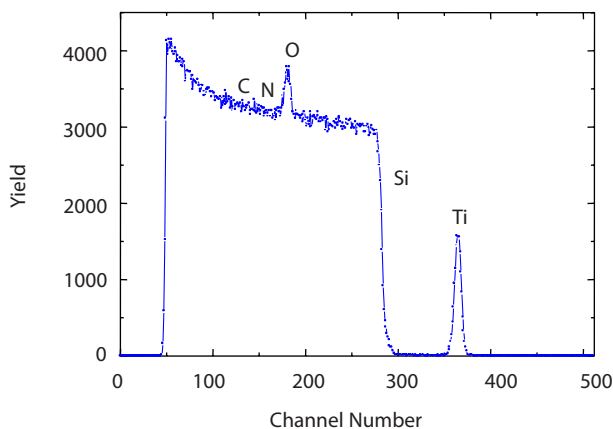
Discussion

NRA uses energetic, low mass ions, such as protons, deuterons or helium-3 to induce nuclear reactions on light elements. The particles emitted by these nuclear reactions can be used to measure the light element contents and profiles in thin films.

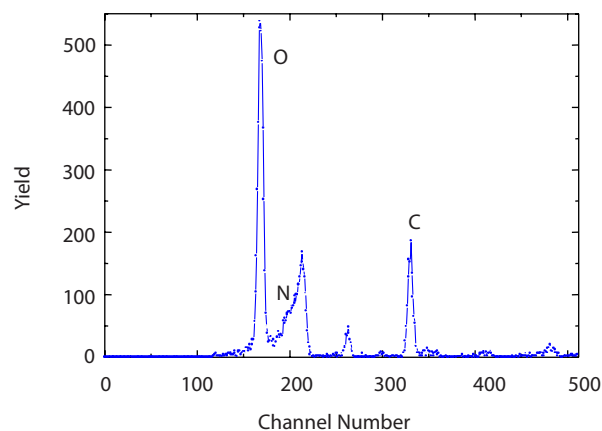
The following reactions are typically used for NRA: ${}^7\text{Li}(p,\alpha)\alpha$, ${}^{11}\text{B}(p,\alpha)2\alpha$, ${}^{12}\text{C}(d,p){}^{13}\text{C}$, ${}^{14}\text{N}(d,p){}^{15}\text{N}$, ${}^{16}\text{O}(d,p){}^{17}\text{O}$ and ${}^{19}\text{F}(p,\alpha){}^{16}\text{O}$. For example, during the ${}^{14}\text{N}(d,p){}^{15}\text{N}$ reaction, a deuteron reacts with a ${}^{14}\text{N}$ atom to form a ${}^{15}\text{N}$ atom and emit a proton. Listed in Table 1 are detection limits for Li, B, C, N, O and F determined at count rates equal to three times background signal levels. The equivalent concentration detection limits in 500Å Si are also listed. NRA is much more sensitive than RBS for measuring light elements, and in combination with RBS provides improved accuracy for thin film composition.

Table 1. NRA Detection Limits for Li, B, C, N, O and F

Element	Detection Limit (atoms/cm ²)	Concentration in 500Å Si
Lithium	5.0E+15	2%
Boron	3.0E+14	0.2%
Carbon	1.7E+14	0.1%
Nitrogen	2.0E+15	0.8%
Oxygen	1.0E+15	0.4%
Fluorine	2.0E+15	0.8%



**Figure 1: 500Å Ti_{0.275}O_{0.61}N_{0.009}C_{0.044}/Si
RBS with 2.275 MeV He**



**Figure 2: 500Å Ti_{0.275}O_{0.61}N_{0.009}C_{0.057}Si_{0.05}/Si
NRA with 1.00 MeV D**

Figures 1 and 2 show RBS and NRA measurement of C, N, and O in TiO_xN_yC_z.

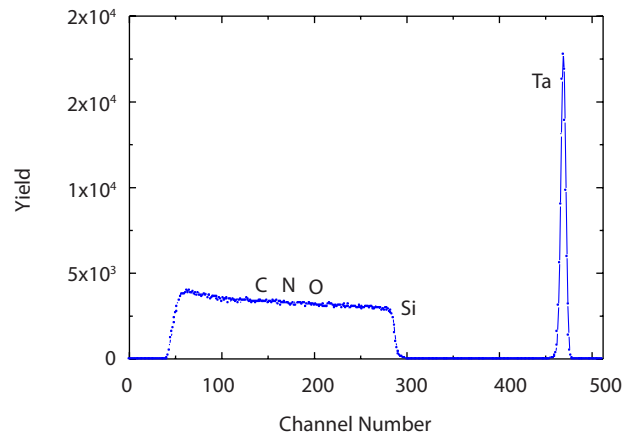


Figure 3: 140\AA $\text{Ta}_{0.525}\text{N}_{0.357}\text{O}_{0.07}\text{C}_{0.044}/\text{Si}$ RBS with 2.275 MeV He

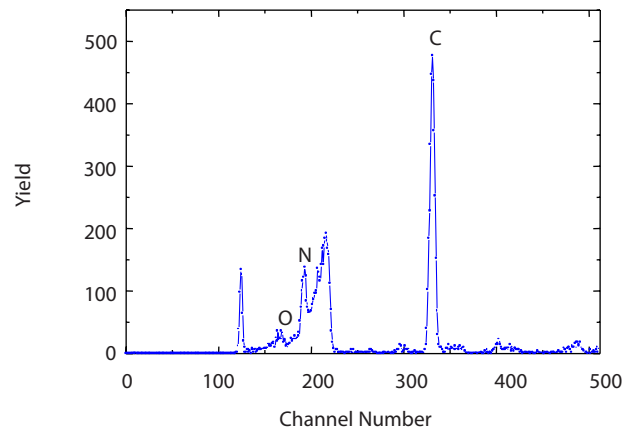


Figure 4: 140\AA $\text{Ta}_{0.525}\text{N}_{0.357}\text{O}_{0.07}\text{C}_{0.044}/\text{Si}$ NRA with 1.00 MeV D

Figures 3 and 4 show TaNxOyCz composition measurement by RBS and NRA.

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