AN 381
Nuclear Reaction Analysis (NRA) for Li, B, C, N, O and F

May 7, 2007 (Version 3.0)

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: $^{7}Li(p,\alpha)\alpha$, $^{11}B(p,\alpha)\,2\alpha$, $^{12}C(d,p)^{13}C$, $^{14}N(d,p)^{15}N$, $^{16}O(d,p)^{17}O$ and $^{19}F(p,\alpha)\,^{16}O$. For example, during the $^{14}N(d,p)^{15}N$ reaction, a deuteron reacts with a ^{14}N atom to form a ^{15}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^3)	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%

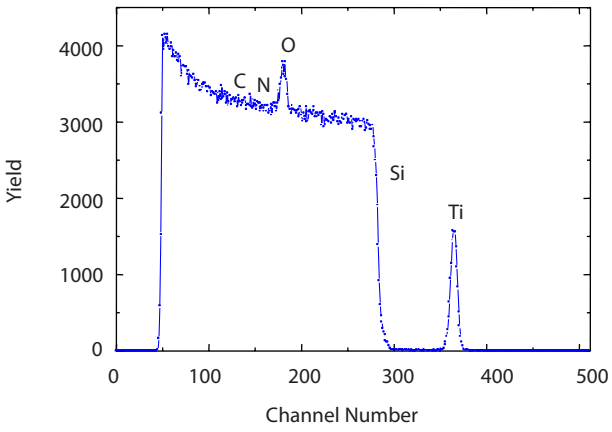

Figure 1: 500Å Ti0.275O0.61N0.009C0.044/Si RBS with 2.275 MeV He

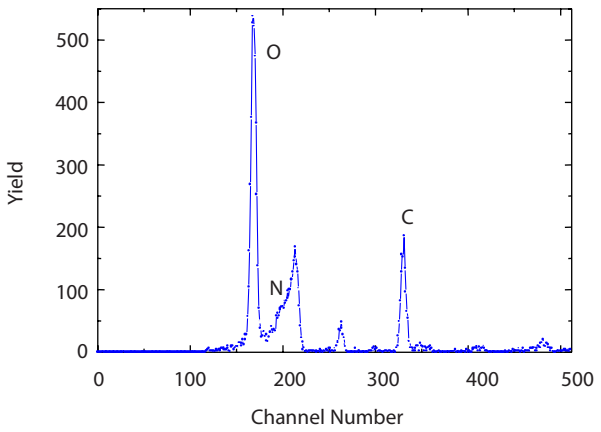

Figure 2: 500Å Ti0.275O0.61N0.009C0.057Si0 .05/Si NRA with 1.00 MeV D

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

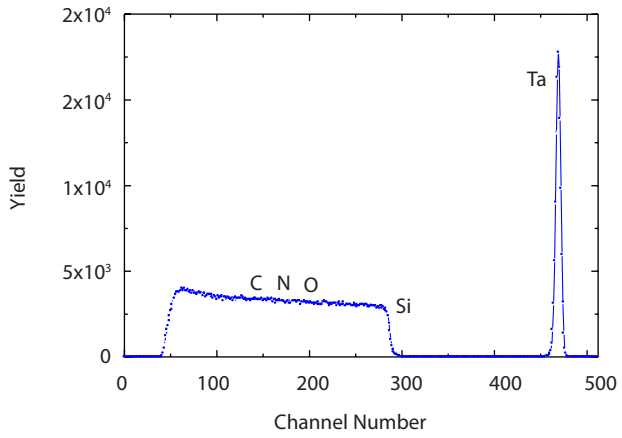

Figure 3: 140Å $Ta_{0.525}N_{0.357}O_{0.07}C_{0.044}$/Si RBS with 2.275 MeV He

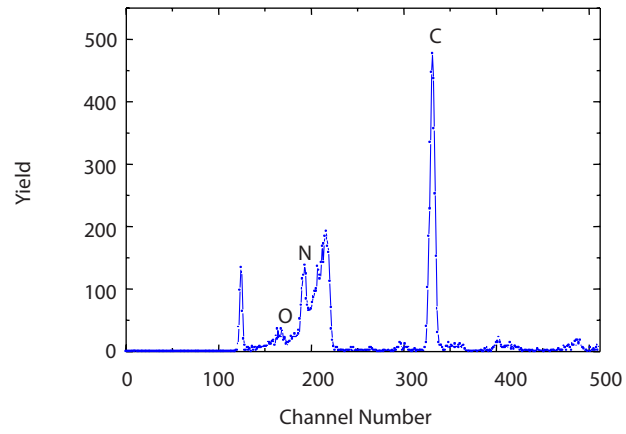

Figure 4: 140Å $Ta_{0.525}N_{0.357}O_{0.07}C_{0.044}$/Si NRA with 1.00 MeV D

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

United States Locations

Tempe, Arizona
+1 480 239 0602 info.az@eaglabs.com
+1 602 470 2655 fax

Sunnyvale, California
810 Kifer Road
+1 408 530 3500 info.ca@eaglabs.com
+1 408 530 3501 fax

1135 E Arques Avenue
+1 408 738 3033
+1 408 738 3035 fax

785 Lucerne Drive
+1 408 737 3892
+1 408 737 3916 fax

Peabody, Massachusetts
+1 978 278 9500 info.ma@eaglabs.com
+1 978 278 9501 fax

Chanhassen, Minnesota
+1 952 828 6411 info.mn@eaglabs.com
+1 952 828 6449 fax

East Windsor, New Jersey
+1 609 371 4800 info.nj@eaglabs.com
+1 609 371 5666 fax

Syracuse, New York
+1 315 431 9900 info.ny@eaglabs.com
+1 315 431 9800 fax

Raleigh, North Carolina
+1 919 829 7041 info.nc@eaglabs.com
+1 919 829 5518 fax

Round Rock, Texas
+1 512 671 9500 info.tx@eaglabs.com
+1 512 671 9501 fax

International Locations

Shanghai, China
+ 86 21 6879 6088 info.cn@eaglabs.com
+ 86 21 6879 9086 fax

Tournefeuille, France
+ 33 5 61 73 15 29 info.fr@eaglabs.com
+ 33 5 61 73 15 67 fax

Frankfurt, Germany
+ 49 (0) 693053213 info.de@eaglabs.com
+ 49 (0) 69307941 fax

Tokyo, Japan
+ 81 3 5396 0531 info.jp@eaglabs.com
+ 81 3 5396 1930 fax

HsinChu, Taiwan
+ 886 3 5632303 info.tw@eaglabs.com
+ 886 3 5632306 fax

Uxbridge, United Kingdom
+ 44 (0) 1895 811194 info.uk@eaglabs.com
+ 44 (0) 1895 810350 fax