Rutherford Backscattering (II)

RBS is a powerful technique for assessing the chemical composition, crystalline quality, and depth-dependent structure of samples.

Chemical composition
- Derives from the fact that the target nucleus has a finite mass
- Different mass of target nucleus (different element) will have a different recoil energy
  \[ \Rightarrow \text{this means the backscattered ion energy will depend on the target nuclei} \]

Crystalline quality
- Derives from the effect of channeling and blocking
- Ions incident along crystalline symmetry directions will be channeled and leads to dramatic reduction of the backscattered intensity
- Ions not incident along crystalline symmetry directions will have higher backscattering intensity at any backscattering angle
- Poor crystalline quality can lead to higher backscattering
- Difference between “aligned” and “random” spectra an indication of the crystalline quality
- Can also see the effects of impurities in the sample

Depth-dependent structure
- Layered samples can be investigated
- Different elemental layers will be distinguishable in the energy-dependent backscattering intensity
- Modeling can lead to a determination of the depth-dependence of the elemental concentrations
- Usually requires some information from the sample grower in order to best model the data
Interesting case: Scandium-rich growth conditions

- leads to high crystalline quality but with N-vacancies, as seen above
Scandium Nitride grown under Sc-rich conditions

STM Image of sample under UHV conditions

FIG. 4. STM image of ScN(001) surface grown under scandium rich conditions. Sample bias $V = +2.0 \text{ V}$; tunneling current = 0.2 nA.

- Phase Stability, Nitrogen Vacancies, Growth Mode, and Surface Structure of ScN(001) Under Sc-rich Conditions
  Hamad A. H. Al-Brithen, Eugen M. Trifan, David C. Ingram, Arthur R. Smith, and Daniel Gall
RBS Study of Sc-rich grown sample

- Phase Stability, Nitrogen Vacancies, Growth Mode, and Surface Structure of ScN(001) Under Sc-rich Conditions
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**Manganese Nitride** grown by molecular beam epitaxy develops into various crystalline phases having different compositions.

The compositions of samples grown with different phase were measured by RBS.

- $\theta$-phase: MnN ($\sim 1:1$ Mn:N)
- $\eta$-phase: Mn$_3$N$_2$ ($\sim 3:2$ Mn:N)
- $\varepsilon$-phase: Mn$_4$N$_1$ ($\sim 4:1$ Mn:N)

**Crystalline Phase and Orientation Control of Manganese Nitride Grown on MgO(001) by Molecular Beam Epitaxy**

Haiqiang Yang, Hamad Al-Brithen, Arthur R. Smith, Eugen Trifan, and David C. Ingram

Results of RBS measurements of samples grown under different conditions resulting in the different phases:

<table>
<thead>
<tr>
<th>Phase</th>
<th>$\theta$-Mn$_2$</th>
<th>$\eta_\perp$-Mn$_3$N$_2$</th>
<th>$\eta_\parallel$-Mn$_3$N$_2$</th>
<th>$\epsilon$-Mn$_3$N</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{N}{N_0}$ (Mn$_{\text{III}}$)</td>
<td>1:1.00</td>
<td>3:2.70</td>
<td>3:2.04</td>
<td>4:1.68</td>
</tr>
<tr>
<td>$f_N = \frac{N}{N_0}$ (%)</td>
<td>50.0</td>
<td>47.0</td>
<td>40.0</td>
<td>30.0</td>
</tr>
<tr>
<td>$f_N = 100% - f_x$ (%)</td>
<td>50.0</td>
<td>53.0</td>
<td>59.0</td>
<td>70.0</td>
</tr>
</tbody>
</table>

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