# 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
  → 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

Example

Scandium Nitride studied by RBS

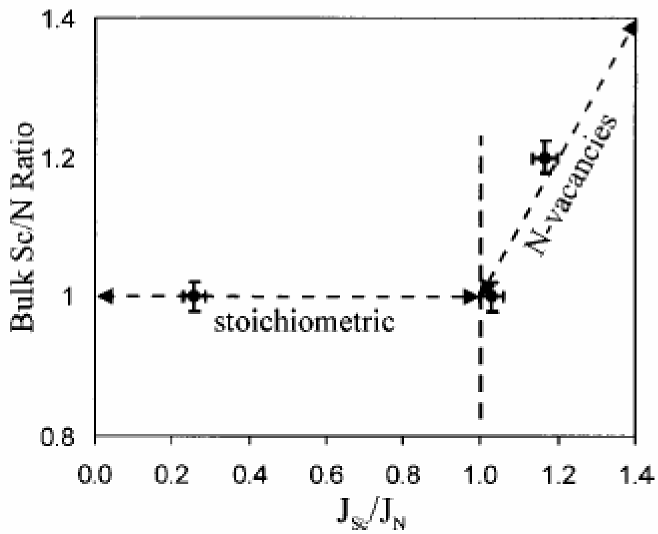


FIG. 5. Incorporated Sc/N concentration calculated from RBS data as a function of $J_{Sc}/J_N$.

**Molecular Beam Epitaxy Control of the Structural, Optical, and Electronic Properties of ScN(001)**
Arthur R. Smith, Hamad A.H. AL-Brithen, David C. Ingram, and Daniel Gall
*J. Appl. Phys.* ***90(4)****, 1809 (2001).*

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

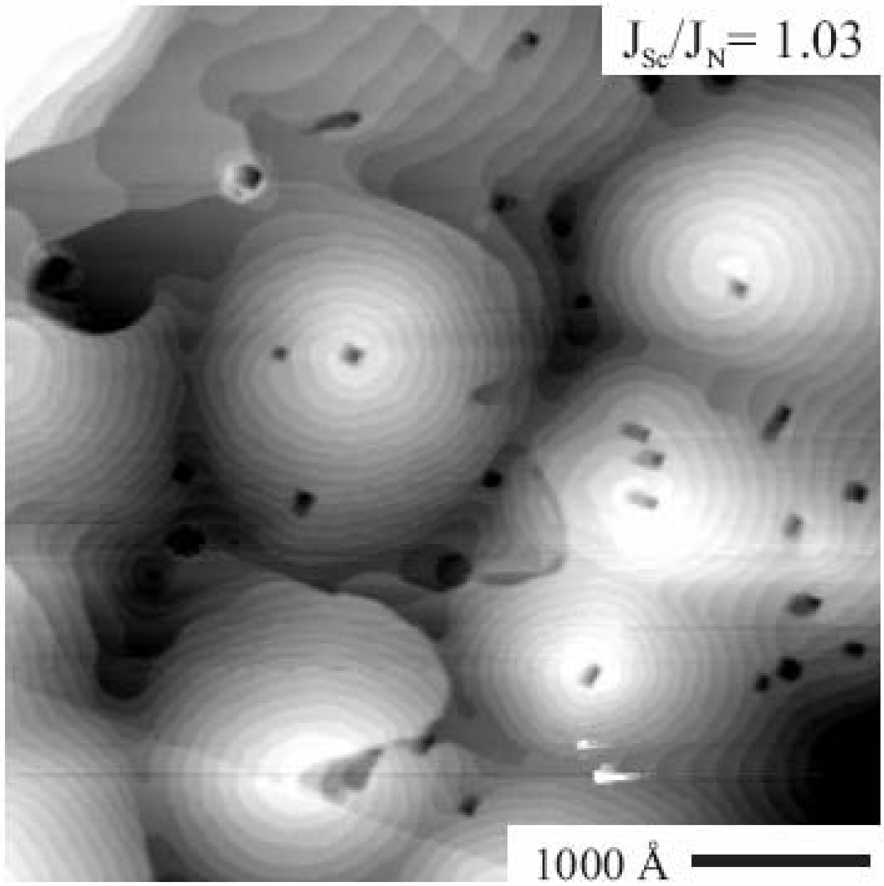


FIG. 4. STM image of ScN(001) surface grown under scandium rich conditions. Sample bias = +2.0 V; tunneling current = 0.2 nA.

- **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

J. Crystal Growth **242**, 345 (2002).

# RBS Study of Sc-rich grown sample

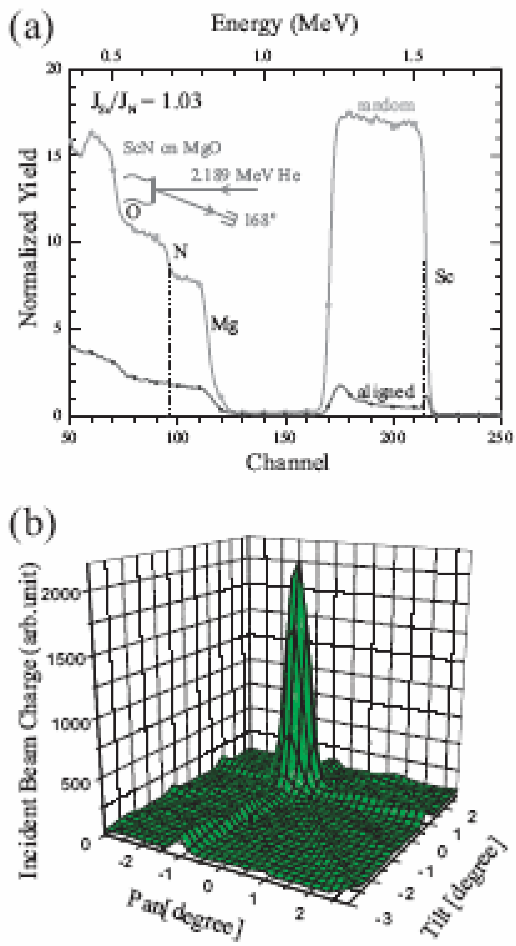


FIG. 2. (a) RBS channeling for ScN(001) film randomly aligned and well aligned with the incident beam. The film was grown under slightly Sc-rich conditions. (b) the RBS rocking scan for the same film.

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Example **Manganese Nitride**

**Manganese Nitride** grown by molecular beam epitaxy develops into various crystalline phases having different compositions

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

θ-phase MnN (~ 1:1 Mn:N)

η-phase Mn3N2 (~ 3:2 Mn:N)

ε-phase Mn4N1 (~ 4:1 Mn:N)

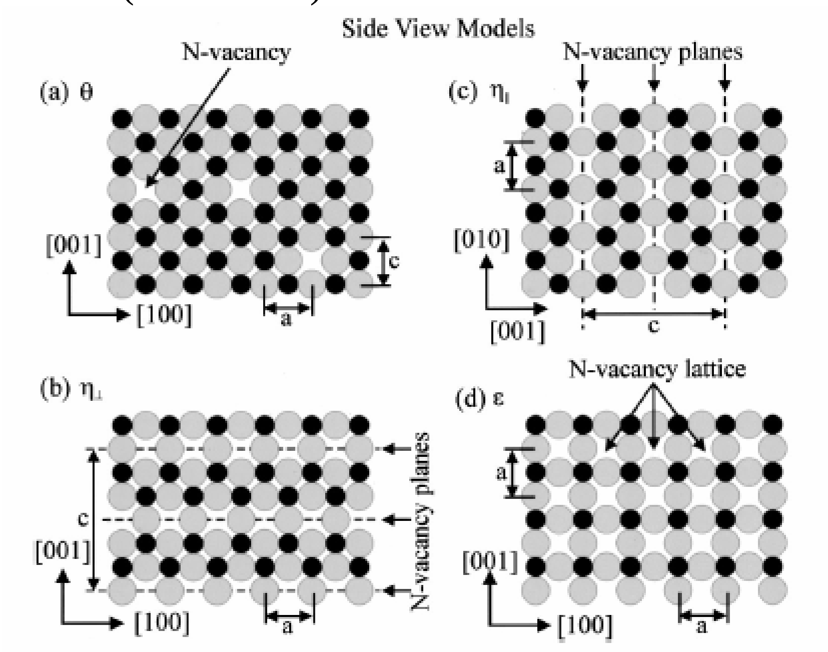


FIG. 4. Side views of schematic model structures of the different phases and orientations. Black dots stand for N atoms; gray circles for Mn atoms: (a) $\theta$ phase, (b) $\eta_{\perp}$ phase, (c) $\eta_{\parallel}$ phase, and (d) $\varepsilon$ phase.

**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

*J. Appl. Phys.* ***91(3)****, 1053 (2002).*

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

TABLE II. Bulk Mn/N composition of the various phases and orientations measured by RBS. The samples are grown at the substrate temperature of 300 °C. The absolute error of each percentage value is 1.0%.

| Phase | $\theta$-MnN | $\eta_{\perp}$-$Mn_3N_2$ | $\eta_{\parallel}$-$Mn_3N_2$ | $\varepsilon$-$Mn_4N$ |
|---|---|---|---|---|
| $\frac{Mn}{N}$ | 1:1.00 | 3:2.70 | 3:2.04 | 4:1.68 |
| $\frac{N}{Mn+N}$ (%) | 50.0 | 47.0 | 40.0 | 30.0 |
| $f_N = \frac{N}{2Mn}$ (%) | 50.0 | 45.0 | 34.0 | 21.0 |
| $f_V = 50\% - f_N$ (%) | 00.0 | 5.0 | 16.0 | 29.0 |

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