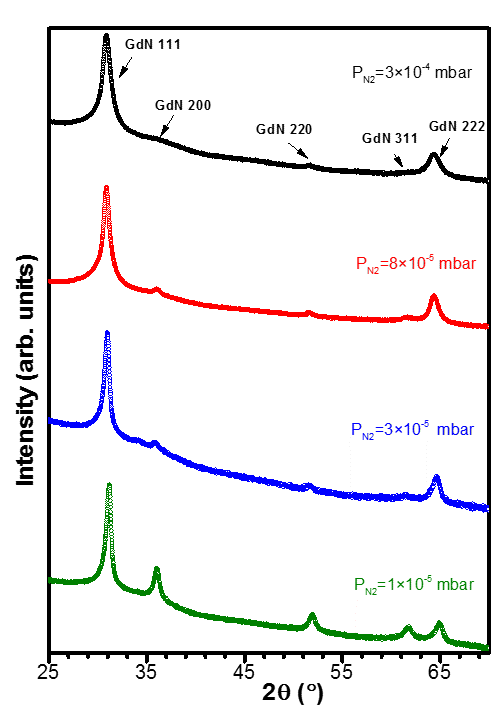
**Coexisting structural phases in the catalytically driven growth of rock salt GdN**

*Ali Shaib*A*\*, Franck Natali*A*, Jay R Chan*A*, Felicia Ullstad*A*, William F Holmes-Hewett*A*, Jackson D Miller*A*, Ben J Ruck*A*, Harry J Trodahl*A

AThe MacDiarmid Institute for Advanced Materials and Nanotechnology, School of Chemical and Physical Sciences, Victoria University of Wellington, PO Box 600, Wellington, New Zealand.

****

**Introduction**

Interest in rare earth mononitride (REN) compounds has immensely increased owing to their potential to offer an alternative to dilute magnetic semiconductors. Most of the RENs share the unique combination of intrinsic ferromagnetic and semiconducting properties providing an opportunity to build a new generation of spintronics devices1,2. Future exploitation of these materials necessitates the understanding of the growth mechanisms and parameters controlling the structural, electrical, and magnetic properties of the REN compounds.

**Aims**

Our work aims to investigate the role of nitrogen vacancies (VN) in polycrystalline thin films of the rock salt GdN, the prototypical REN. This work explores the formation of a secondary GdN phase associated to the VN level in the film (GdN-II), and its coexistence with the near-stoichiometric “intrinsic” GdN phase (GdN-I) through investigating the structural, electrical, and magnetic properties of GdN films grown with different VN levels.

**Fig. 1.** 2θ-θ XRD diffractograms of GdN thin films grown under N2 pressure of 1x10-5, 3x10-5, 8x10-5 and 3x10-4 mbar

**Methods**

Gd metal was deposited with an electron gun on fused silica in the presence of molecular nitrogen (N2) partial pressure ranging between 1×10-5 and 3×10-4 mbar. N2 reacts spontaneously with Gd at the surface to form a GdN layer, even in the absence of activated N2. X-ray diffraction (XRD) scans and Raman spectra were used to characterize the crystallographic properties. Resistivity and Hall effect measurements were performed at ambient temperature, and the magnetic properties of the films were investigated down to 4 K.

**Results and conclusion**

We studied the correlation between the structural, electrical, and magnetic properties of the catalytically driven growth of GdN. XRD measurements display a strong (111) preferential orientation for all N2 pressures and the signature of a secondary phase of GdN (GdN-II) with a smaller lattice constant that develops with the increase of N-deficient regions (Fig. 1). Raman spectra, electrical and magnetic results support correlating this GdN-II phase to VN. Simultaneously, we observe an increase of the Curie temperature with the higher VN levels, i.e., lower N2 growth pressure, with results emphasizing the soft ferromagnetic nature of GdN-II. In conclusion, this work reports key aspects of the growth of polycrystalline GdN thin films of importance for the exploitation of the RENs, including preferential growth and the coexistence of two (111)-oriented phases supported by X-ray diffraction measurements, Raman spectroscopy, and electrical and magnetic measurements.

**References**

1. Natali, F. et al. (2013). Rare-earth mononitrides. Prog. Mats. Sci. 58(8),  1316-1360.
2. Awschalom, D.D. & Flatté, M.E. (2007). Challenges for semiconductor spintronics. Nature Physics 3(3), 153.

\*Corresponding author’s email: ali.shaib@vuw.ac.nz