Control of Metallic Indium Formation During Atomic Hydrogen Cleaning of InN{0001} Surfaces

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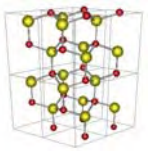
InN {0001}

Wurtzite: a=3.54Å c=5.70Å



- Potential candidate for future applications in LED, LD, Photo detectors, Solar cells, HF and HP devices, etc.

BUT

- InN is difficult to clean being susceptible to electronic and structural damage.
- Furthermore metallic In is easily formed. Any preparation method requires control of In droplet formation.

ATOMIC HYDROGEN CLEANING (AHC)

CLEANING OF InN IS NON-TRIVIAL

- Annealing problems: InN has a lower dissociation temperature than In_2O_3 [1].
- Sputtering issues: Preferential sputtering of N limits sputtering methods [2].

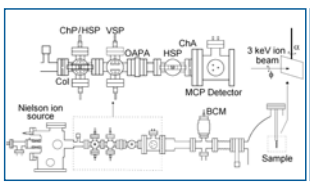
THEREFORE USE ANOTHER APPROACH

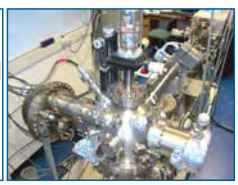
- AHC has been applied to many different semiconductors.
- H* is highly reactive.
- Reacts with O and C atoms in the surface region.
- Reaction products desorbed via low temperature annealing.

An optimised AHC process should give a clean, well-ordered, atomically flat, stoichiometric surface.

EXPERIMENT

- CAICISS, LEED and XPS
- Sputter ion gun, Thermal gas cracker and Target heating up to 800 °C
- Use FAN code to simulate and interpret CAICISS data [3]





SURFACE CLEANING

Samples:

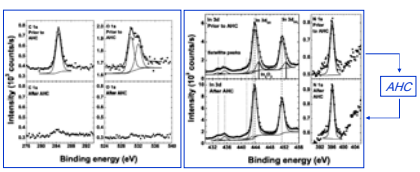
R799: InN(000$\bar{1}$) : N polarity GS1532: InN(0001) : In polarity

Initial AHC Method:

- 8 kL dose at 300 K (chamber pressure at $5x10^{-6}$ mbar).
- 8 kL dose at 450 K.
- Anneal at 575 K for 2 hours in UHV.
- Allow sample to cool to room temperature.

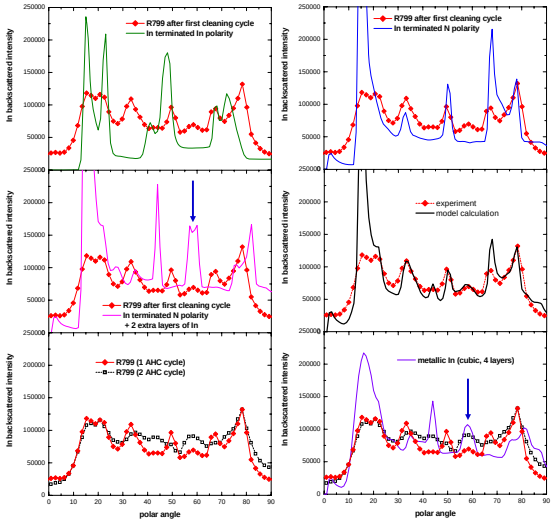
LEED (1x1) @ 79.6 eV

XPS (from Ref. [4])



Well ordered and clean surface BUT excess In

CAICISS Results of initial cleaning method of R799



- polarity determination is therefore possible, even for not perfectly clean InN surfaces.
- the model simulation predicts 50% of the surface covered with metallic In droplets.
- after a 2nd AHC cycle even more metallic In is formed.

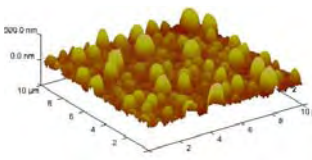
60° feature is solely related to metallic In formation

SURFACE CLEANING

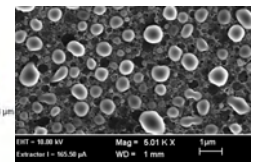
More severe AHC Method:

- 16 kL dose at 550 K with subsequent annealing for 60 min at 550 K
- Allow sample to cool to room temperature.

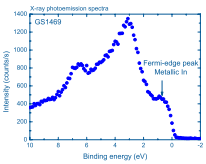
AFM



SEM



XPS



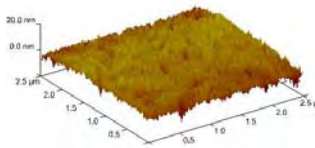
Greater metallic In droplets are formed

OPTIMIZED SURFACE CLEANING

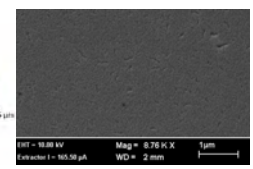
Improved AHC Method:

- 2.7 kL dose at 500 K with subsequent annealing for 30 min at 460 K
- 3.6 kL dose at 460 K with no subsequent annealing
- 4.5 kL dose at 470 K with subsequent annealing for 30 min at 540 K
- Allow sample to cool to room temperature at each step.

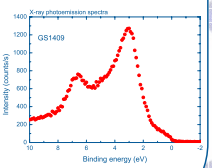
AFM



SEM



XPS



No metallic In droplets are formed

CONCLUSIONS

- A surface cleaning procedure for InN has been developed.
- Polarity determination is still possible, even if the surface is not perfectly clean.
- The 60° peak in CAICISS polar angle scans was found to be characteristic of metallic Indium droplet formation.

REFERENCES

[1] T. Ohashi et al., J. Crystal Growth 237-239 (2002) 1022.
[2] S. Krischok et al., Surf. Sci. 566-568 (2004) 849.
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