

Highly effective protective film on InP semiconductor Made in liquid Ammonia (-55°C): a new route for III-V passivation

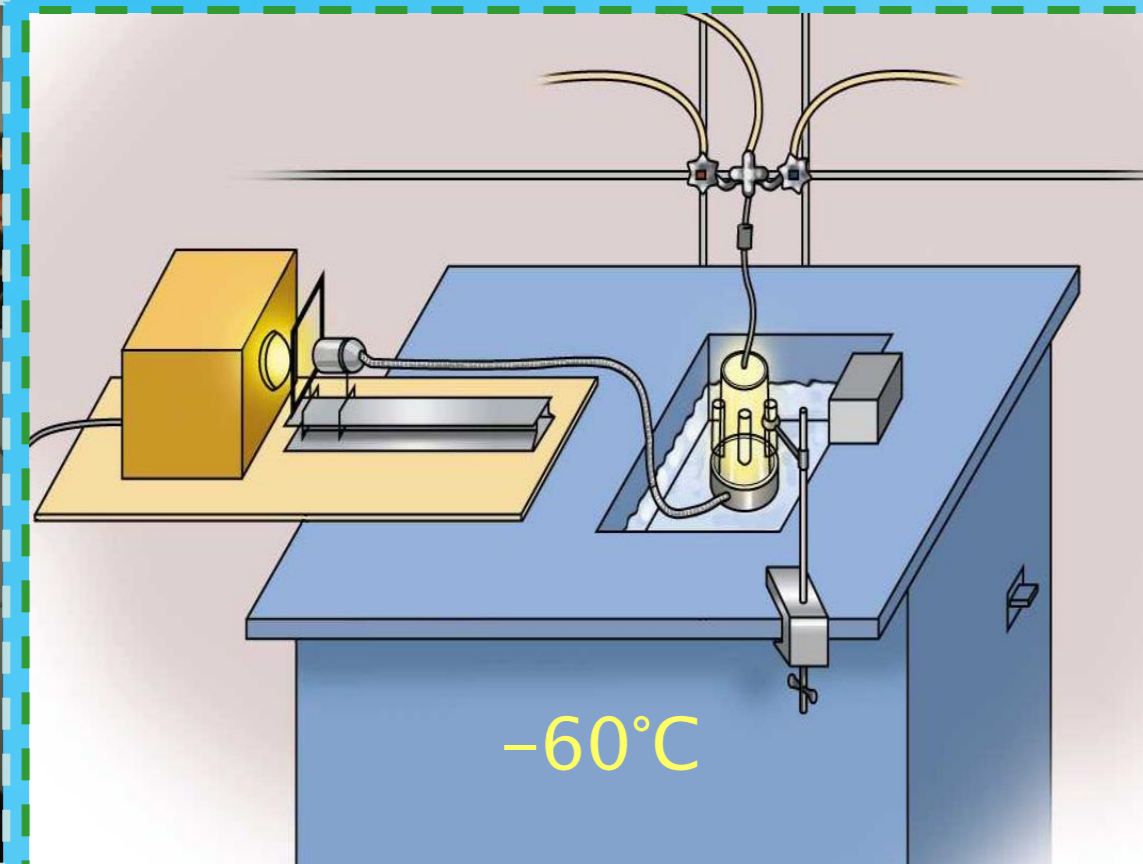
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ammonia condensation

Schematic view of the Cell
used for the film formation

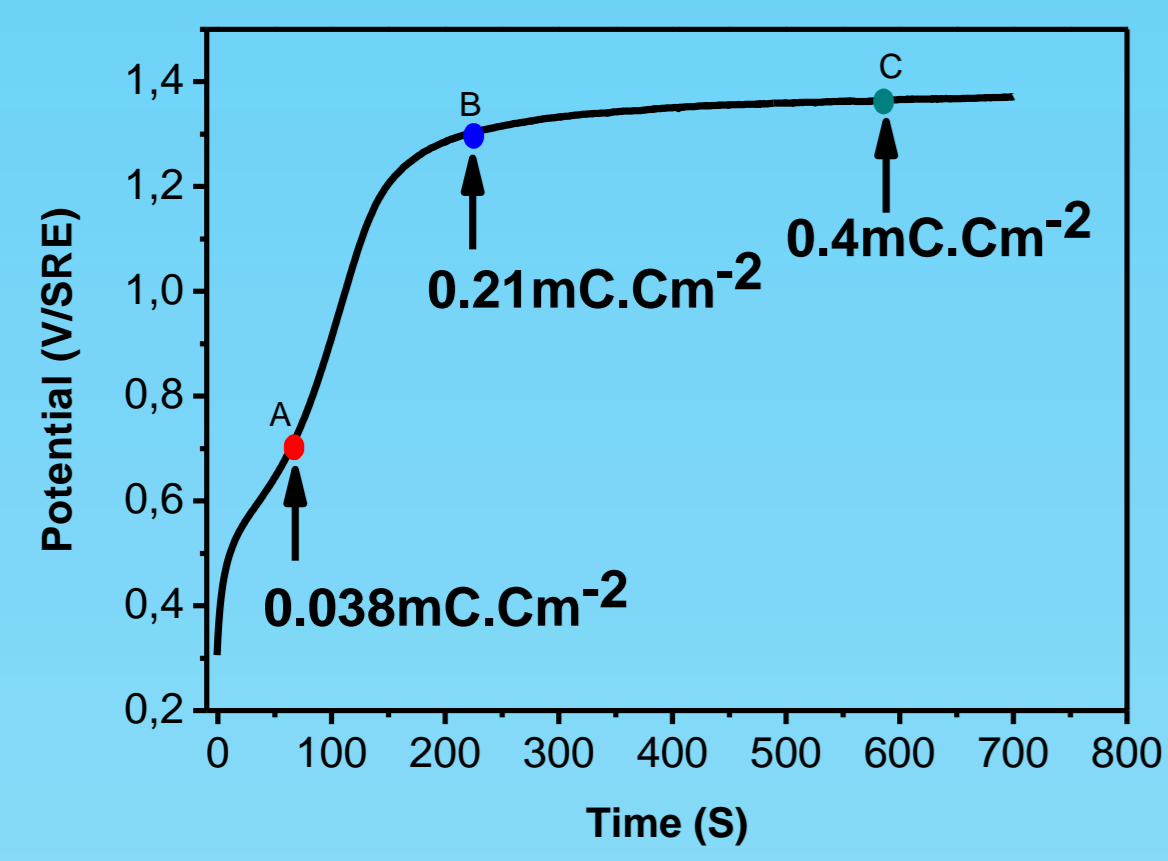


The context :

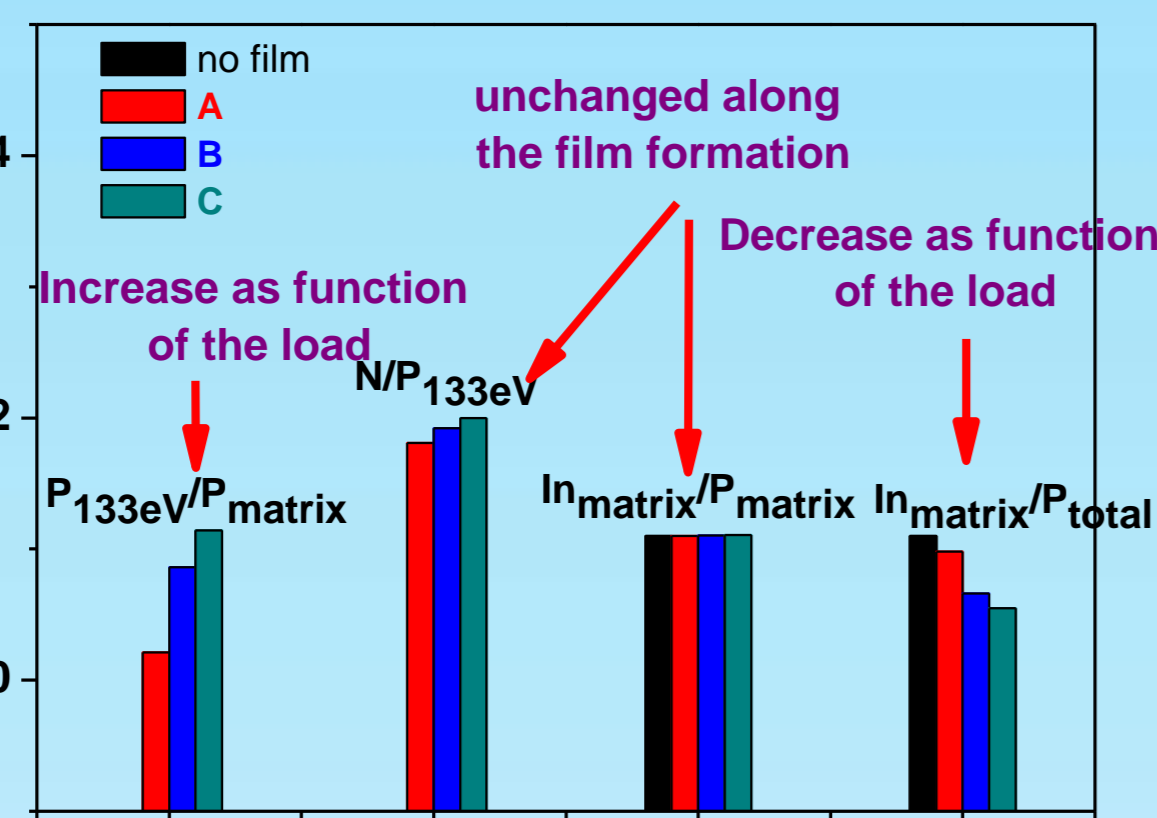
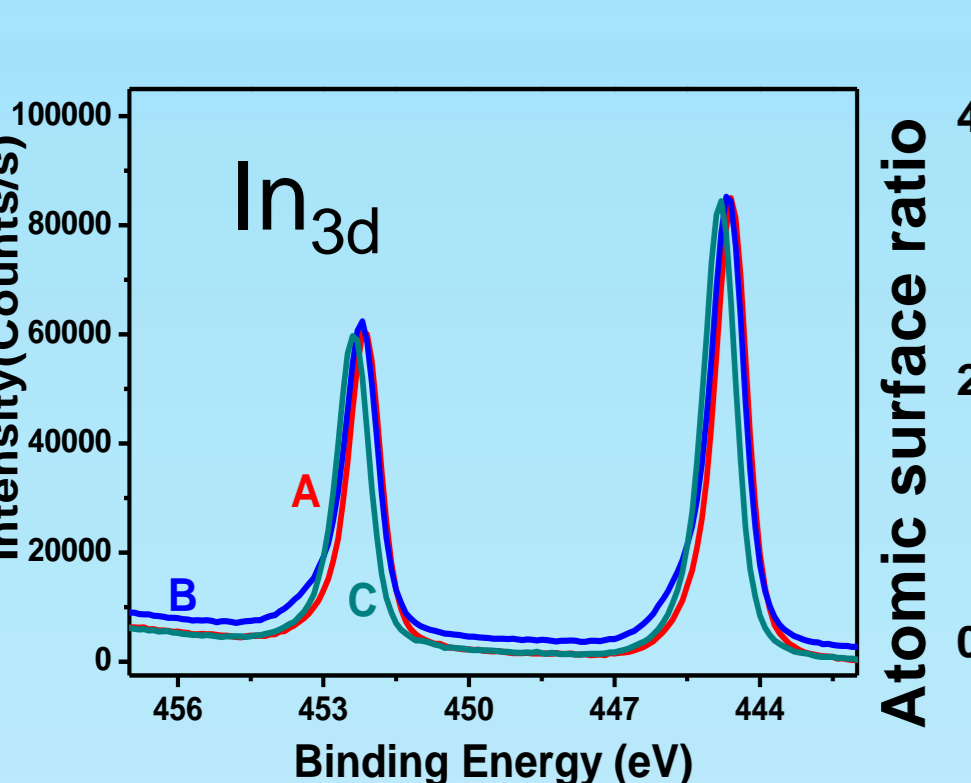
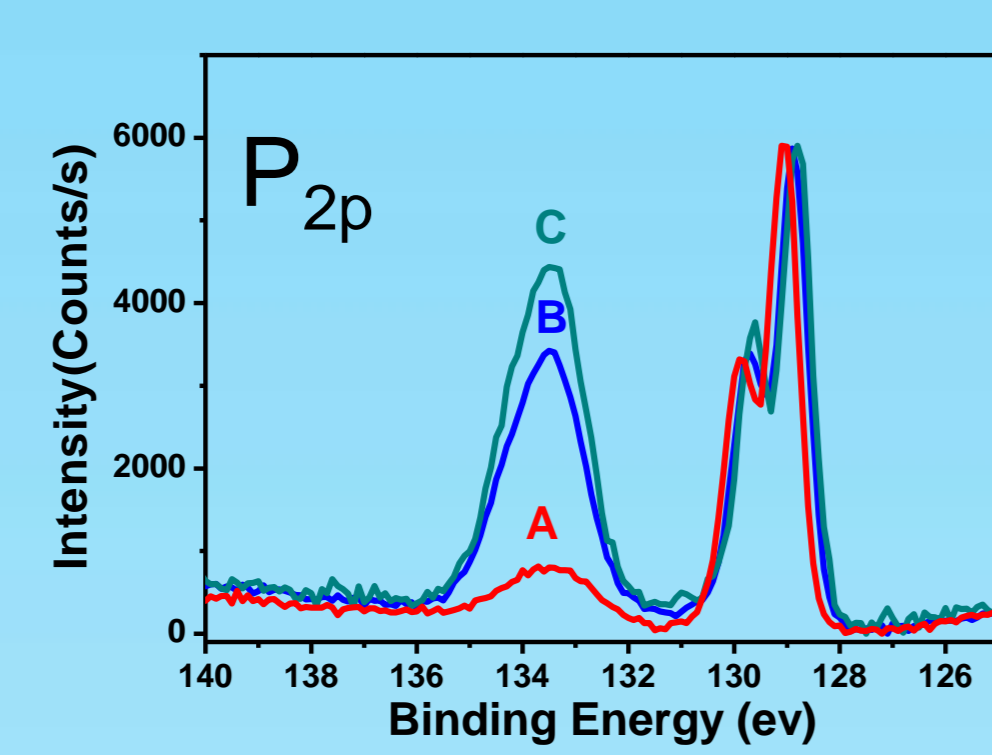
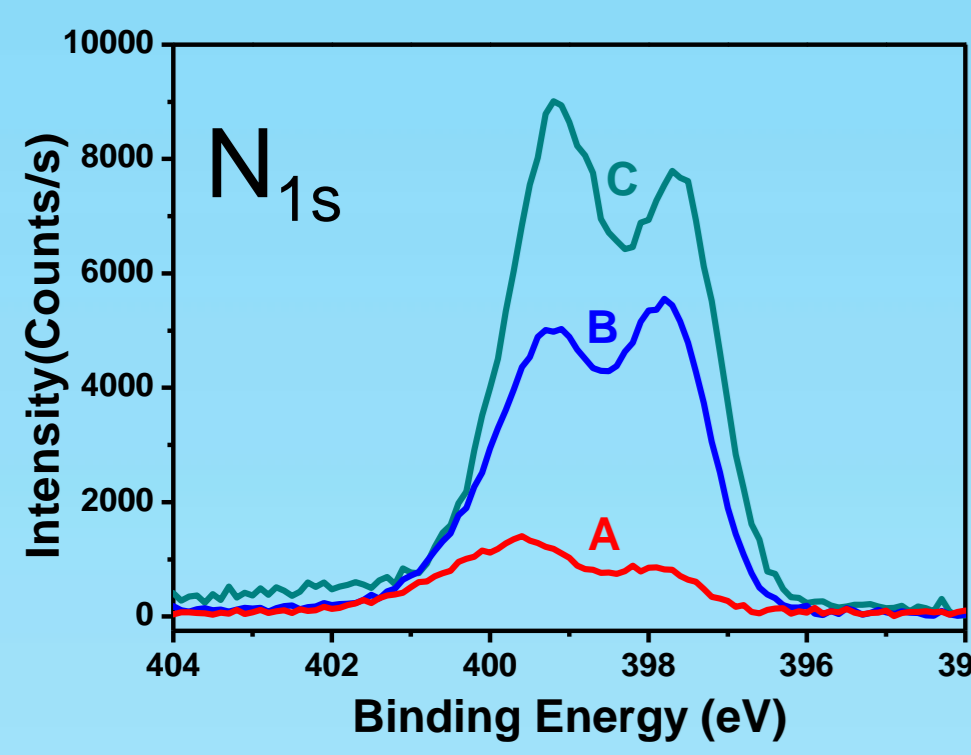
The development of all types of optoelectronic devices based on InP materials has been hampered by instability toward oxidation under ambient conditions.

Evolution of the film chemistry
in galvanostatic mode according the charge

Experimental condition : Galvanogram of InP-n under illumination in liquid ammonia. Acidic condition: pH=1; [NH₄Br]=0.1M; i=0.1μA; J=0.714μA/cm²; Ref: SRE; T= -55°C.



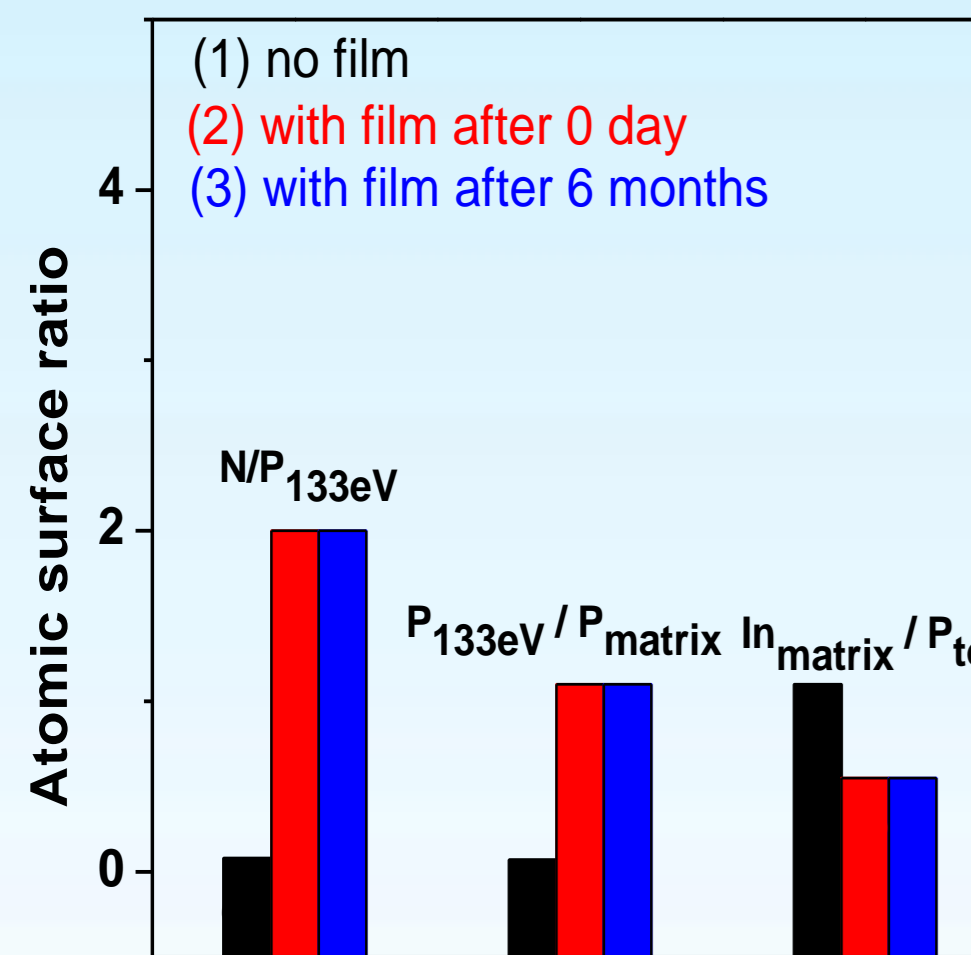
XPS Analysis:



- ❖ Increase of various components atomic (N1s and P2p at 133 eV) as a function of the load
- ❖ Unchanged N/P ratio along the film formation.
- ❖ Unmodified Indium peaks and Phosphorus matrix peaks during the galvanostatic treatment.

Evolution in time (in ambient condition)

Experimental condition : film formed after 0.5 mC.cm⁻²

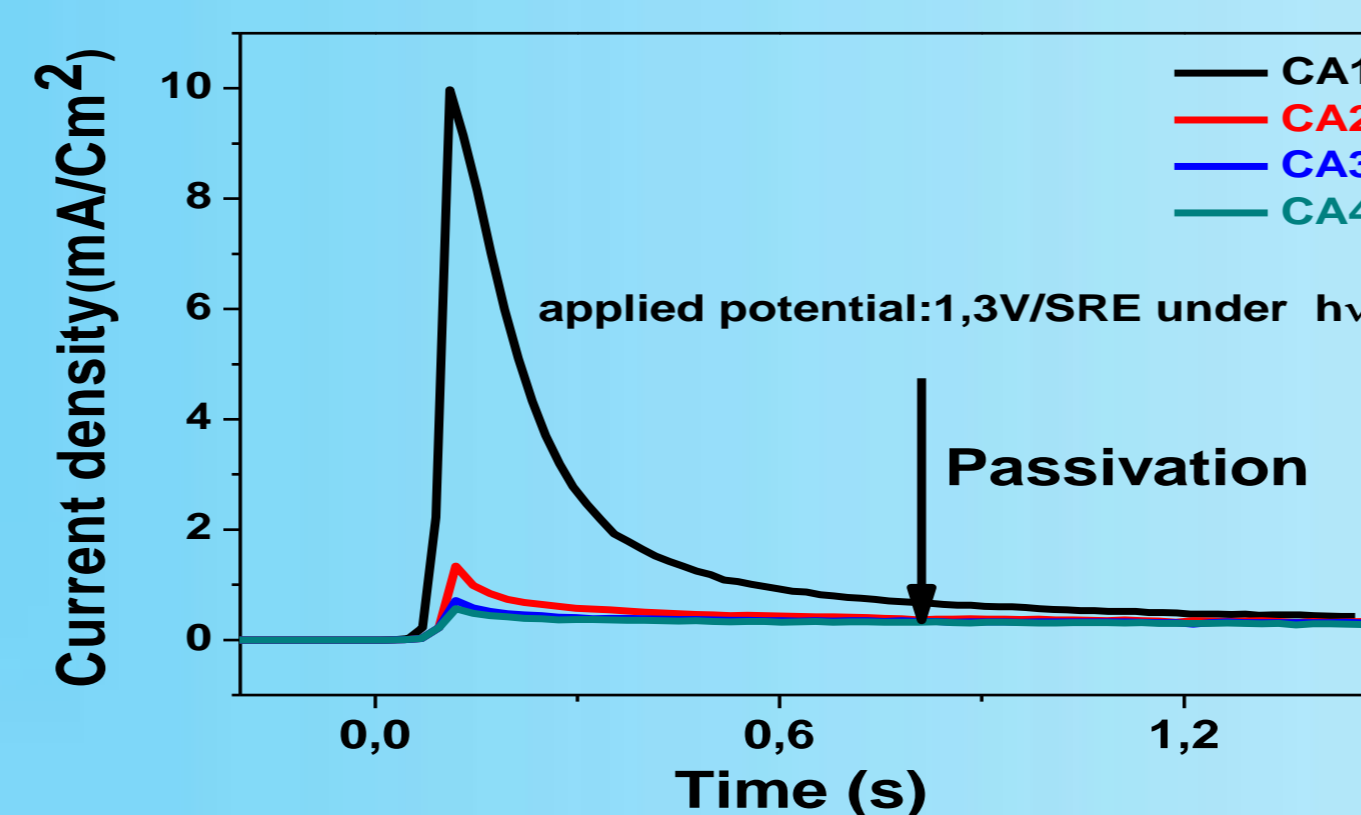


- Oxygen level remains low
- No ageing effect after 6 months
- No oxides surface: entirely recovered by the film
- → passivation of InP
- Constant ratios

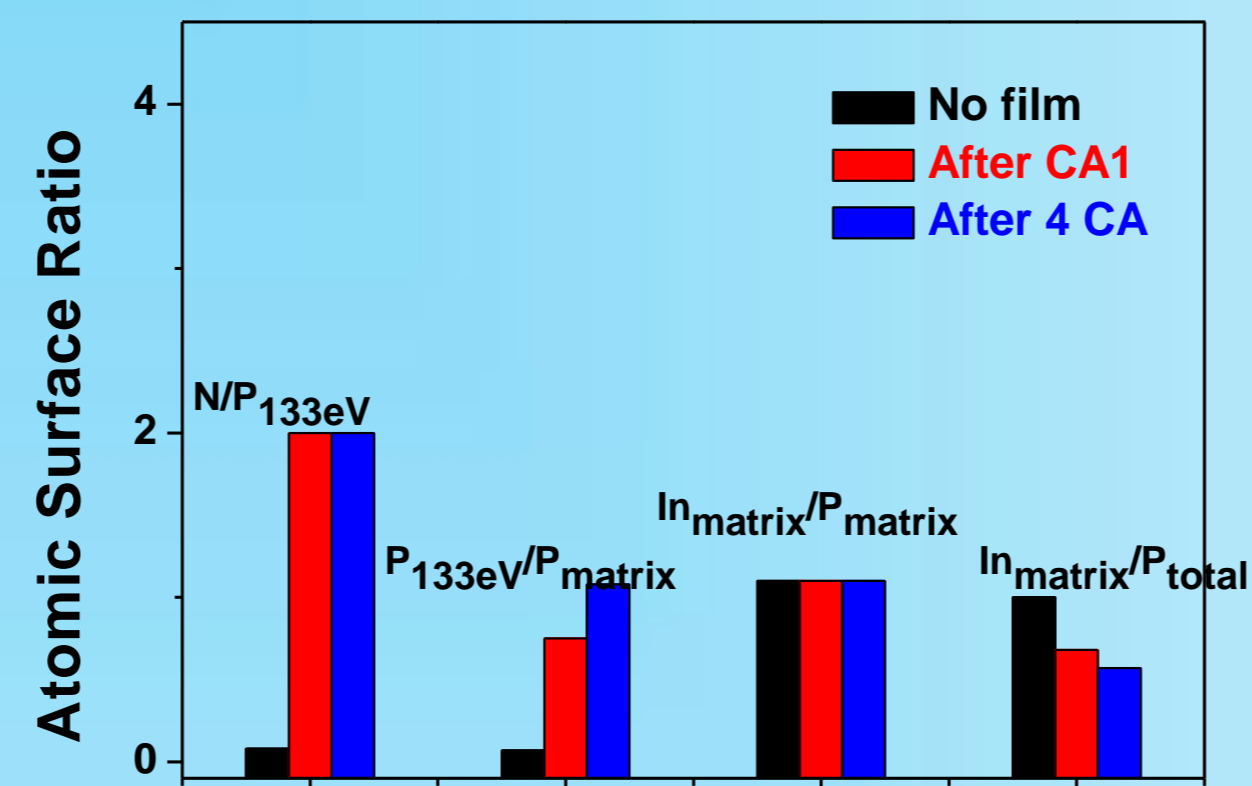
High chemical stability of the protected InP surface by the galvanostatic treatment

PASSIVATION evidency

Experimental condition : Several CA on InP-n



❖ Decrease of pic current as a function of CA: passivation



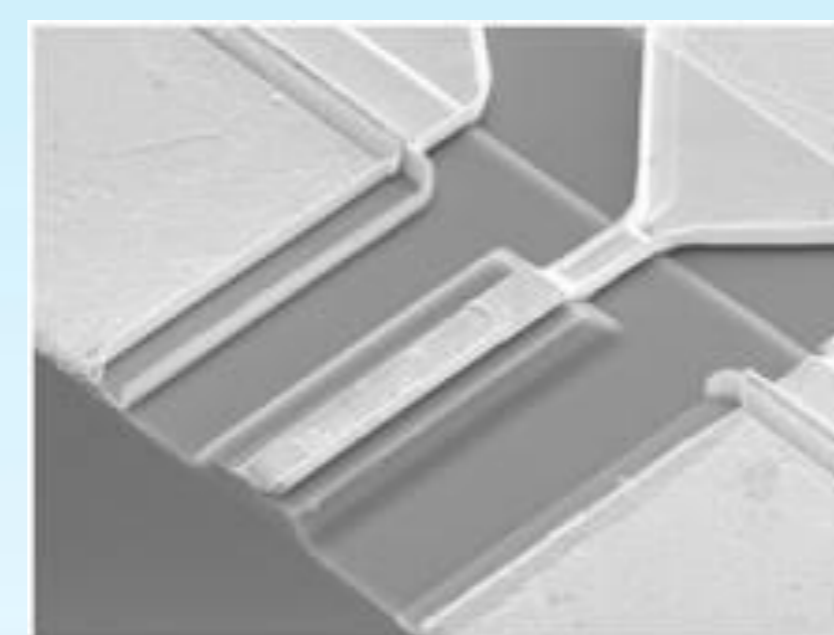
- Increase of components atomic P2p at 133 eV after several Chrono-Amperometry (CA)
- Unchanged N/P ratio along the film formation.
- Unmodified Indium peaks and Phosphorus matrix peaks after several Chrono-Amperometry (CA).

Passivation on InP-n observed after several CA

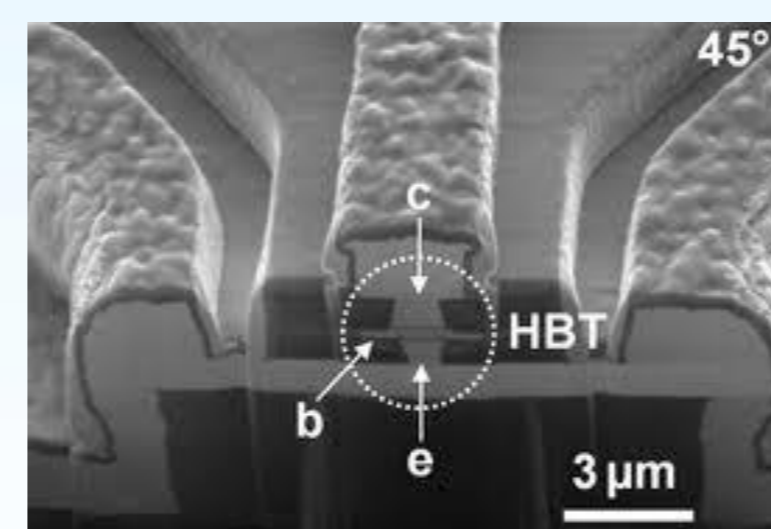
Uses and Purposes



Wave Guide: a wave InP/air



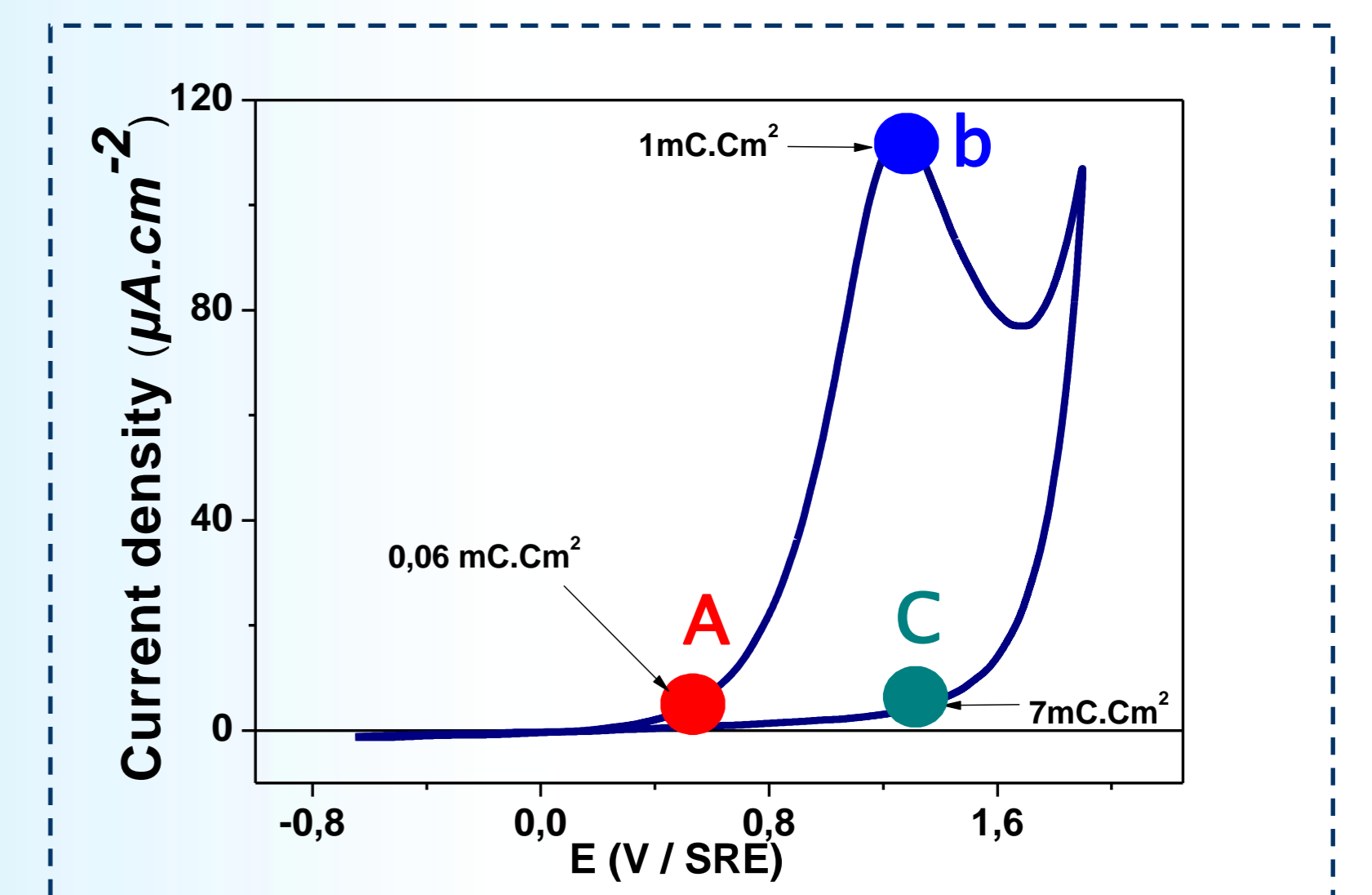
Travelling-Wave Photodiode: a Photodetector InP



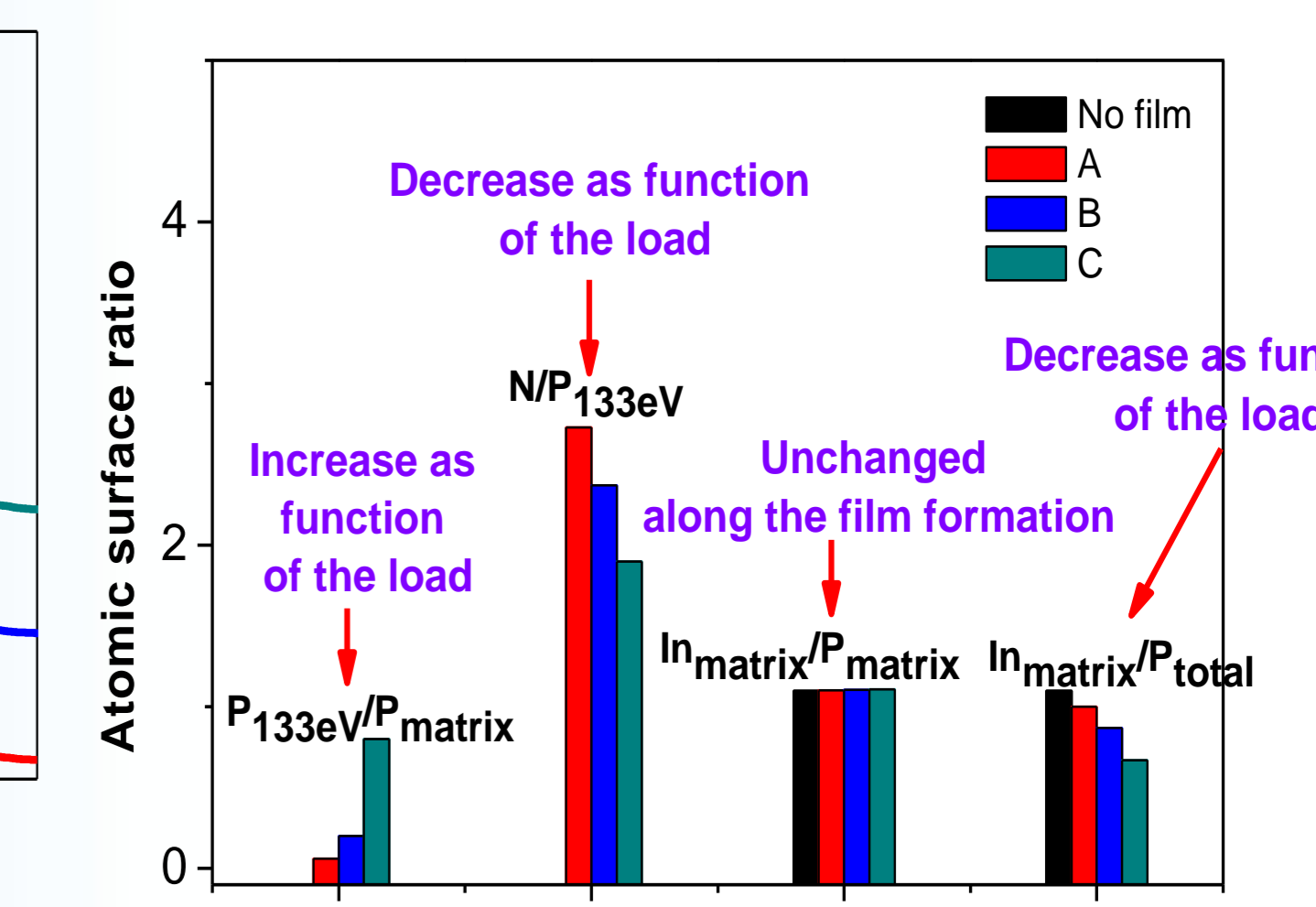
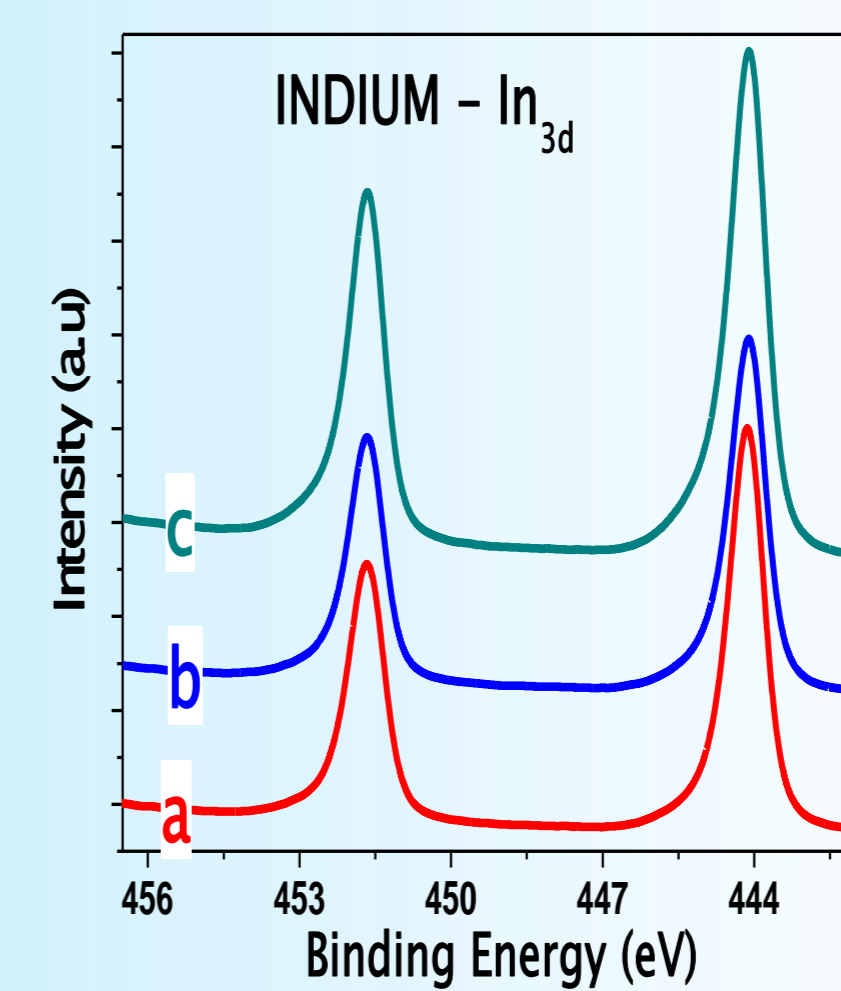
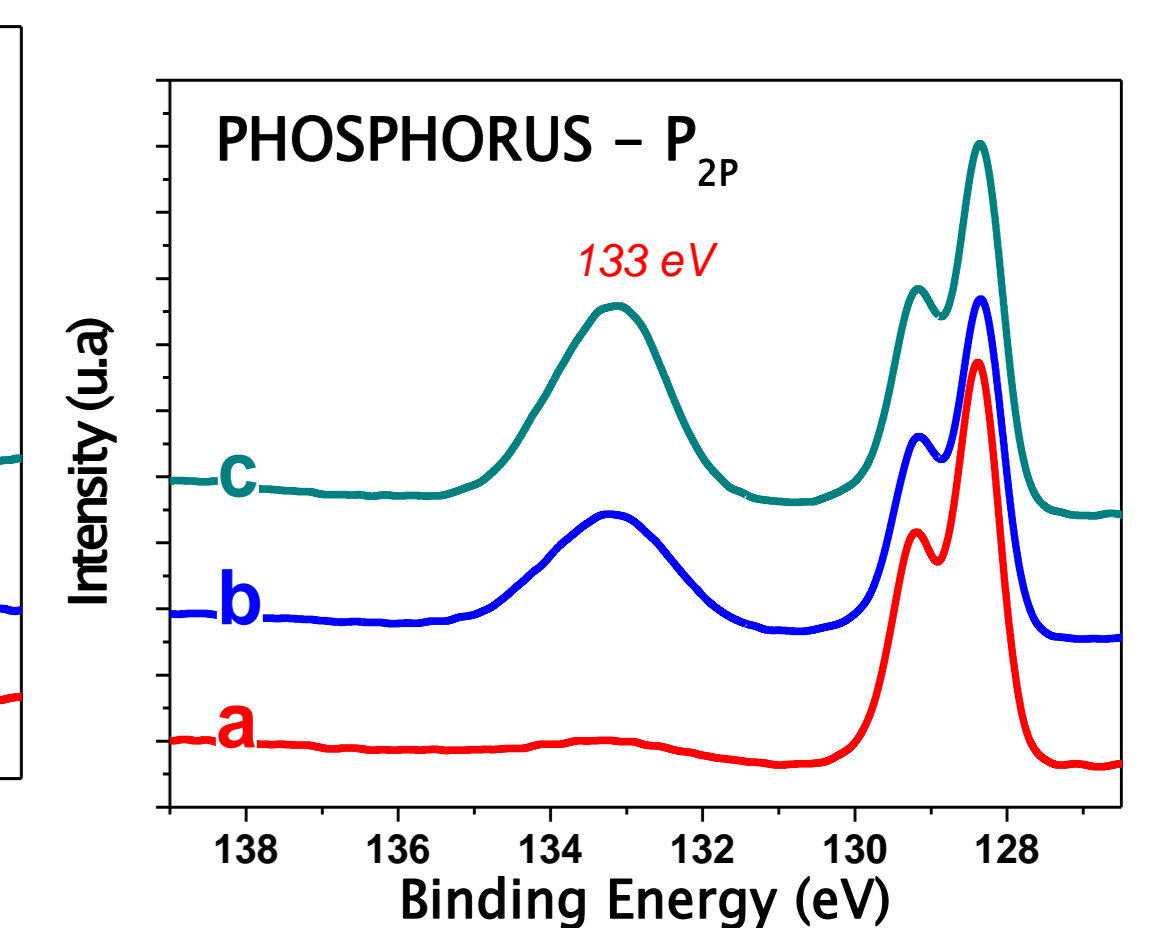
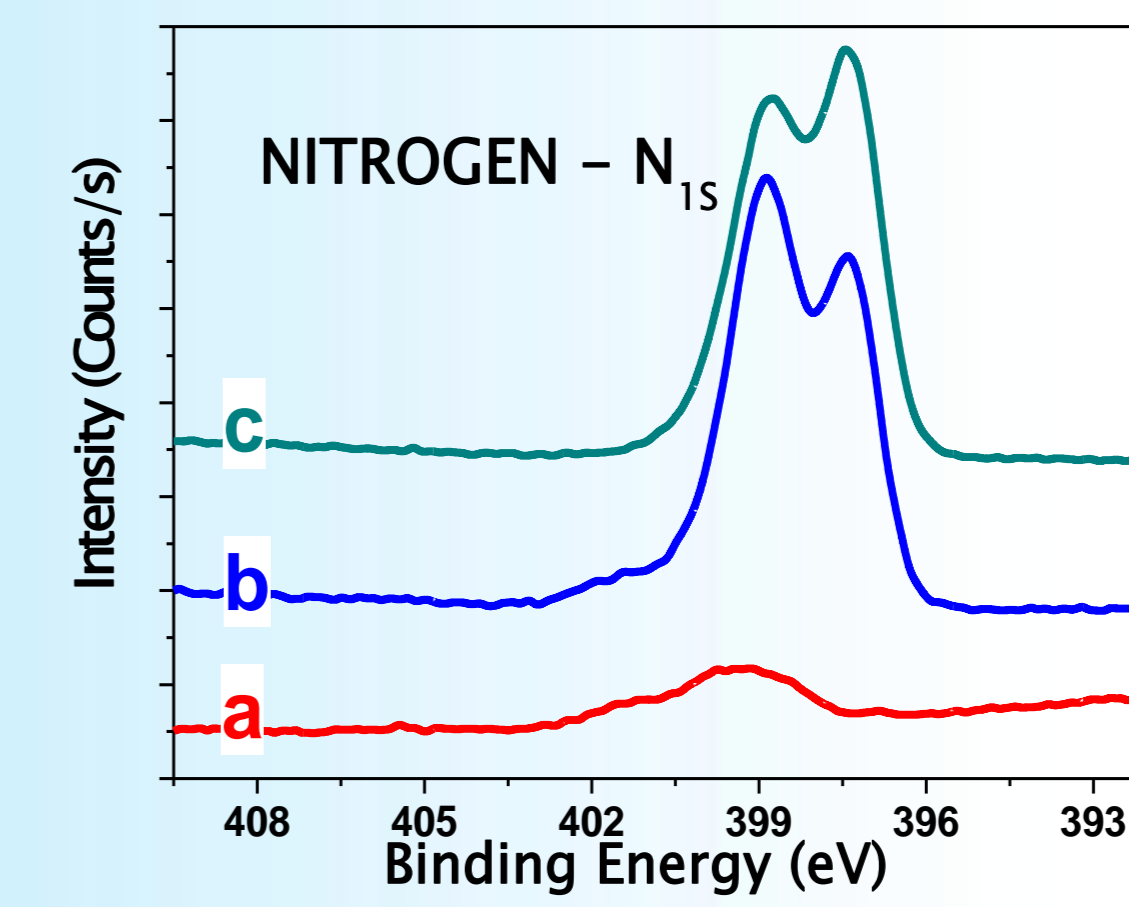
HBT_InP_InGaAs: a bipolar transistor InP/InGaAs

Evolution of the film at different steps
on the anodic wave

Experimental condition: Voltamperogram of InP-n anodic current under illumination in liquid ammonia. Acidic condition: pH=1; [NH₄Br]=0.1M; v=20 mV/s; Ref: SRE; T= -55°C.



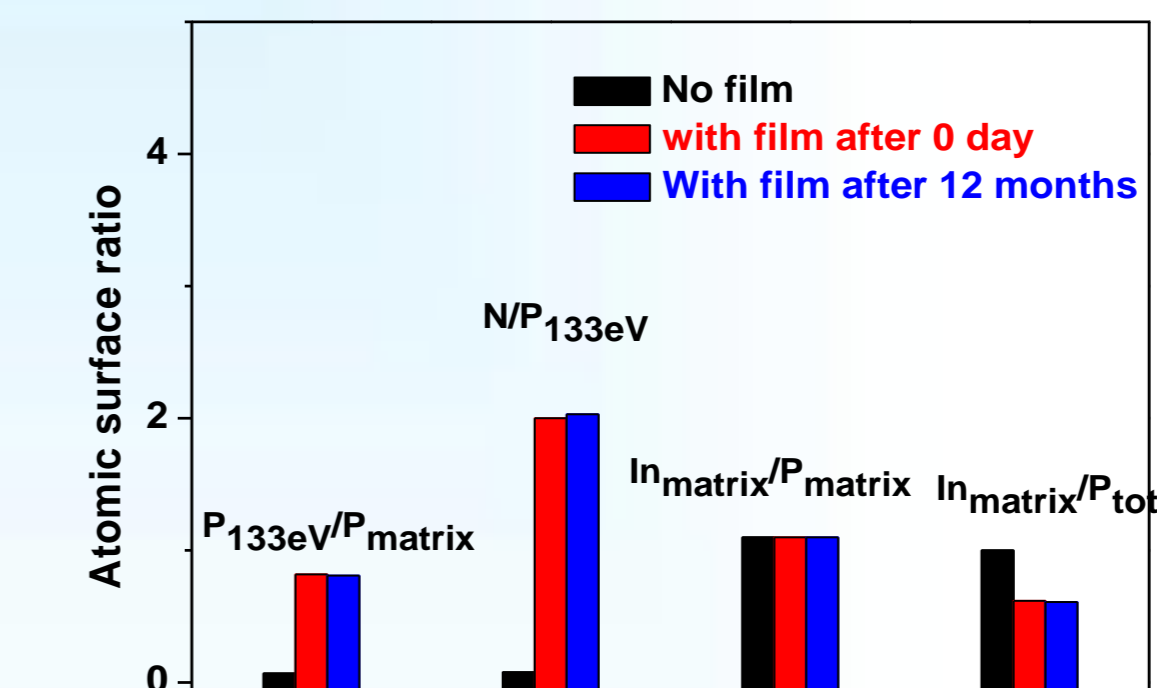
XPS Analysis:



- ❖ Decrease N1s/P2p_{133eV} and In/P2p_{total} ratio as a function of the load
- ❖ The In/P2p_{matrix} ratio remains constant
- ❖ Increase of the ratio P2p_{133eV}/P2p_{matrix}

Evolution in time (in ambient condition)

Experimental condition : film formed after an anodic wave



- Constant ratios
- No oxides surface: entirely recovered by the film
- No ageing effect 12 months

High chemical stability of the surface
for a charge between 5-8mC.cm⁻²

CONCLUSIONS & PERSPECTIVES :

- Passivation phenomenon is shown by potentiostatic mode (CA) : decrease of pic current
- For both electrochemical methods (galvanostatic and cyclic voltammetry) :
 - the formation of the protective is evidenced.
 - the increase of the **N1s** and **P2p_{133eV}** components is observed as a function of the charge.
- Highly air stability of the InP matrix : the film acts as a passivation layer.
 - a phosphazene like film : << **H₂N-P=NH** >> is assumed from XPS studies.

- ❑ Passivation on InP by electroless mode: no current or potential requirement
- ❑ Passivation on mixed surface like In_{1-x}Ga_xAs_{1-y}P_y : essential step to consider corresponding treatments
- ❑ Opening way: the pattern forming.
- ❑ Preliminary investigations on the Solar Energy field: INSIS 2012