Improved surface and interface properties of InP

R.R.Sumathi*, M.Udhayasankar and J.Kumar

Crystal Growth Centre, Anna University, Chennai-600 025, India.
****Presently at: I. Physics Institute, Justus-Liebig University, D-35392 Giessen, Germany.***

EPS-12, Budapest, Hungary.

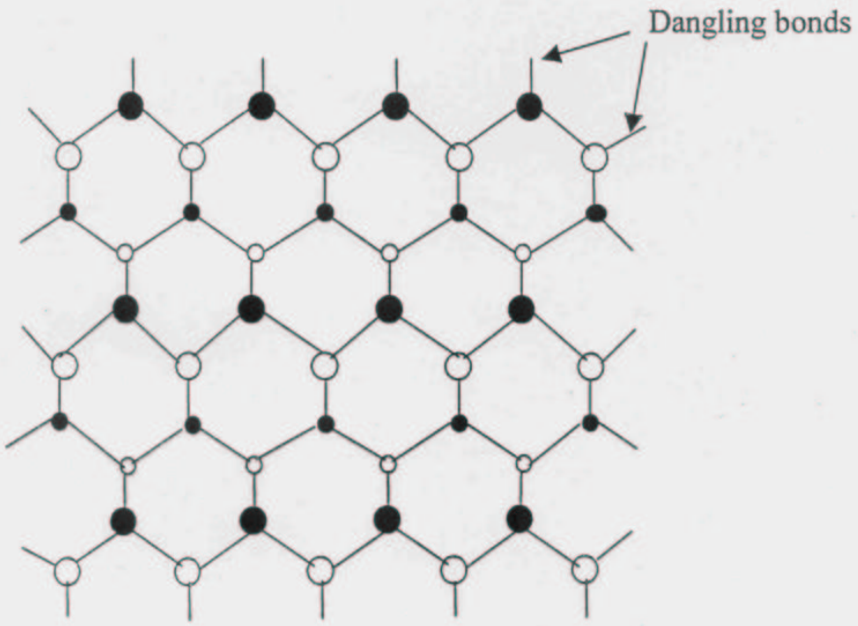


Figure 1.1 Zinc-blende lattice projected on (110) face showing the dangling bonds on the surface

Problem addressed:

- Surface Fermi-level pinning is a very serious problem in indium phosphide.
- The Fermi-level pinning limits the rapid development of InP based devices.

Possible solution for the problem:

- To reduce the surface states, thereby unpin the Fermi-level in indium phosphide (InP) by proper surface preparation and effective passivation schemes

Our approach:

Surface polishing:

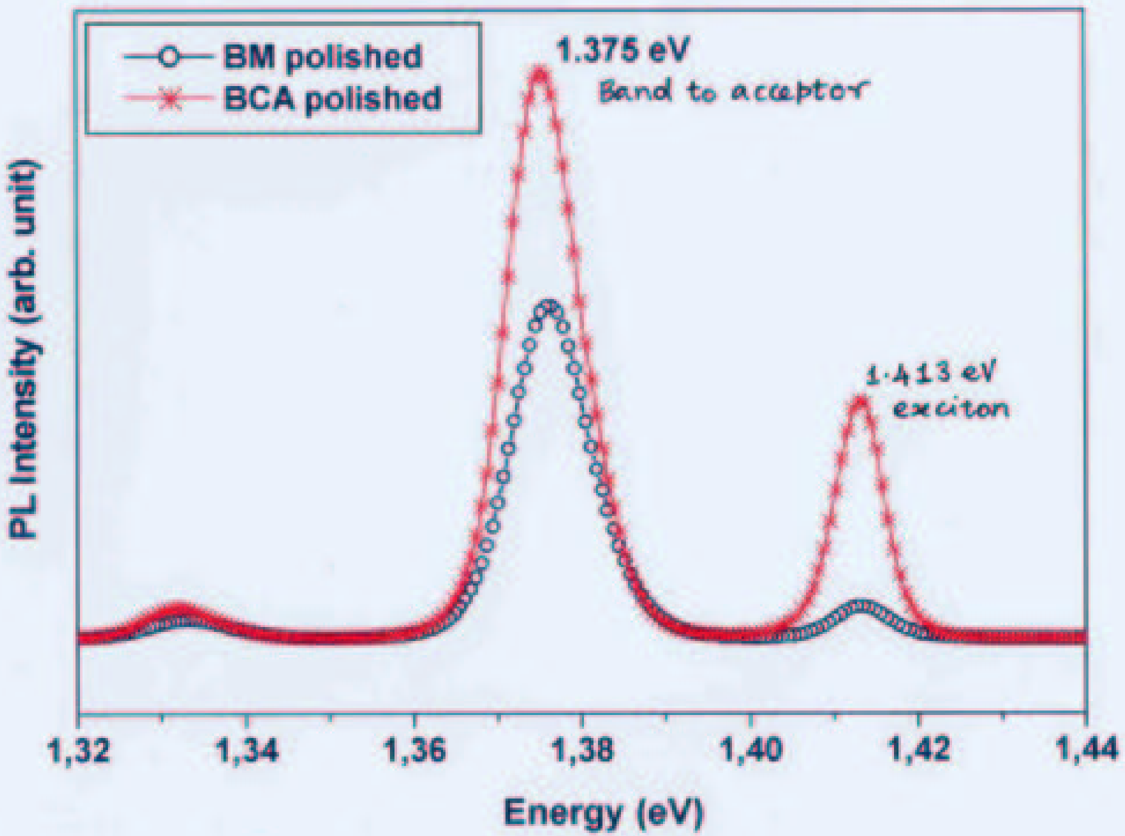
- **A new polishing solution, HBr:K2Cr2O7:H2O (BCA) has been developed and it has been compared with conventional bromine-methanol (BM) solution.**

Surface passivation:

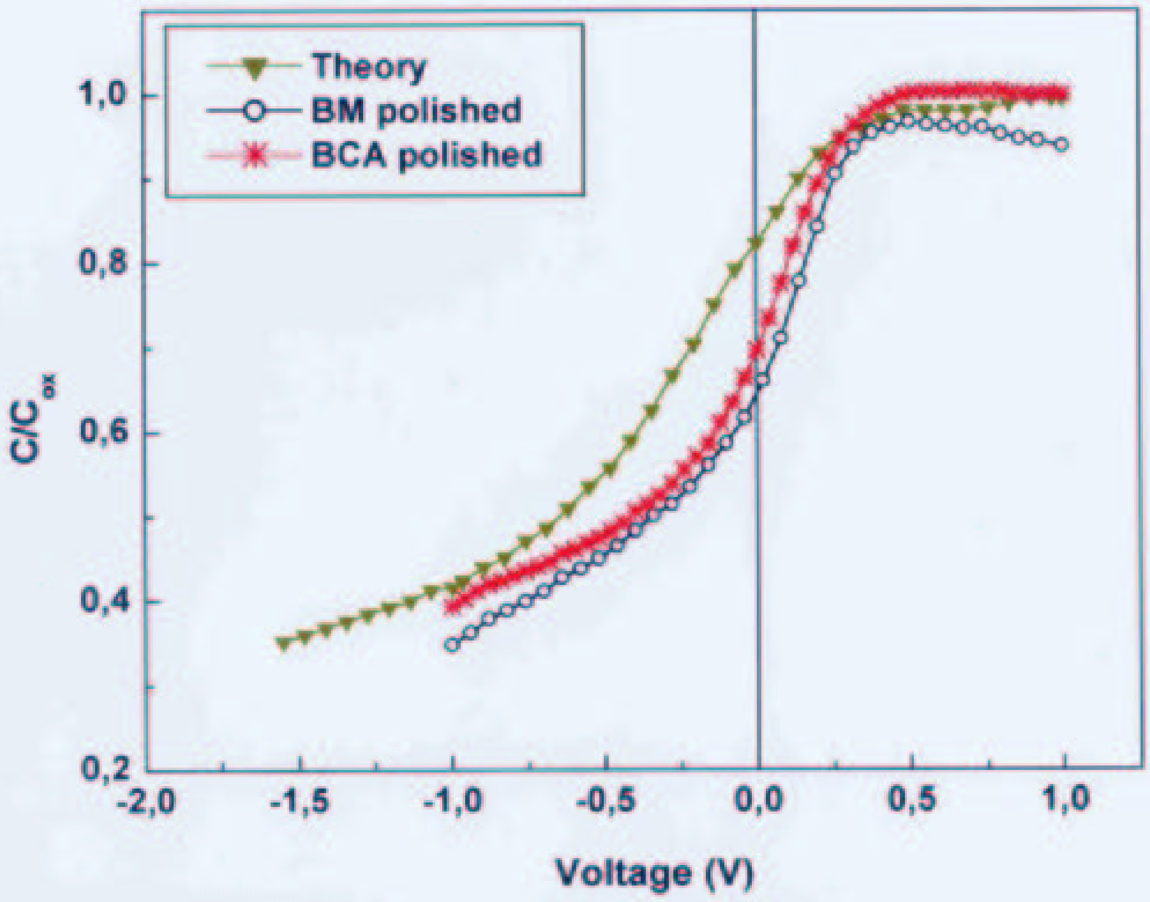
- **Cadmium sulfide (CdS) has been identified as a better passivating agent for InP and CdS passivation has been carried out using simple chemical bath deposition (CBD) method.**

CdS passivation mechanism:

- **As the bonding in InP is mainly covalent, there will be a large perturbation of the valence-state energy at the surface**
- **But constituents of II-VI compounds have a larger electro negativity difference, indicating that the bonds are ionic in nature**
- **the electron wave functions of the ions do not overlap sufficiently to induce midgap states**
- **Thus insulator/II-VI interface should behave more ideally than insulator/III-V counterpart**



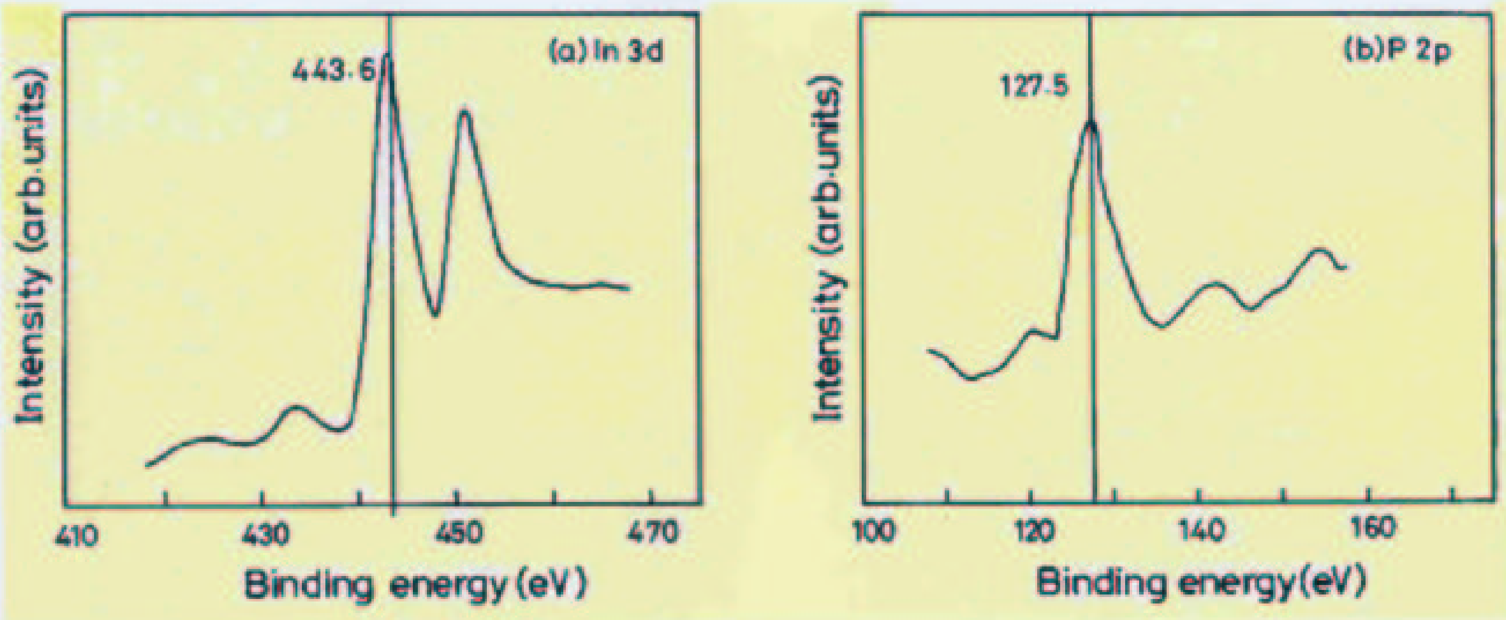
LT *PL spectra of (a) BCA and BM polished InP surface*



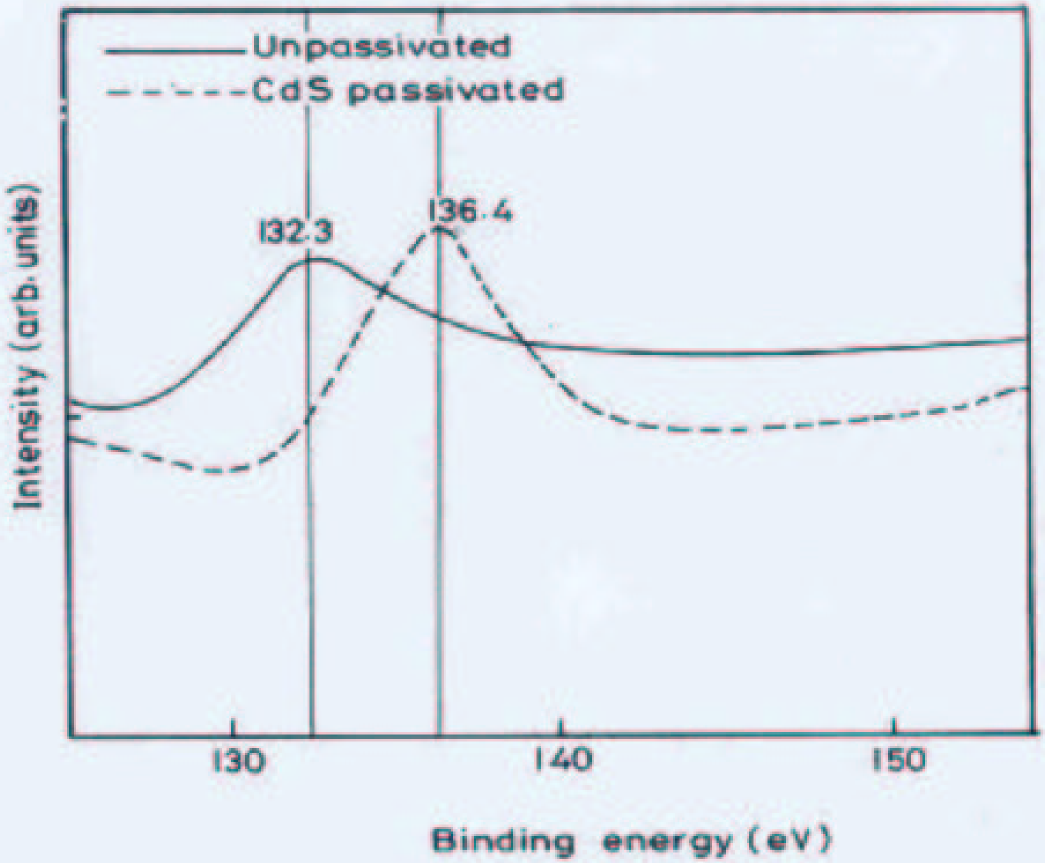
For BM Polished Sample,
$N_{ss} = 9 \times 10^{10}\ cm^{-2}\ eV^{-1}$

For BCA Polished Sample,
$N_{ss} = 6 \times 10^{10}\ cm^{-2}\ eV^{-1}$

Theoretical and experimental C-V curves for N_{SS} calculation



XPS spectra of CdS passivated InP showing the absence of native oxides



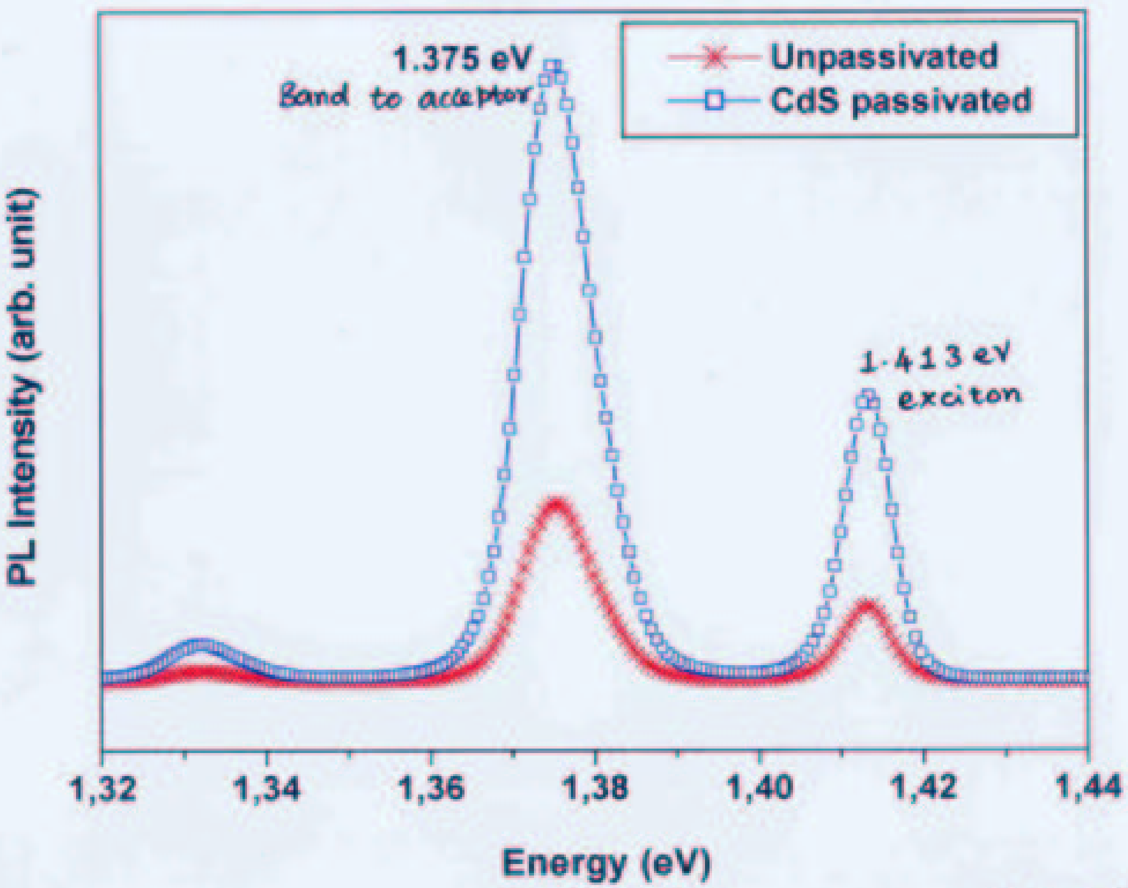
XPS spectra of P 2p peak of unpassivated and CdS passivated InP

Possible mechanism for formation of P_2O_5:

- **During anodic oxidation of InP, both indium oxide (In_2O_3) and phosphorus oxide (P_2O_5) can be formed. In_2O_3 is conductive oxide, whereas P_2O_5 is a high resistive oxide.**

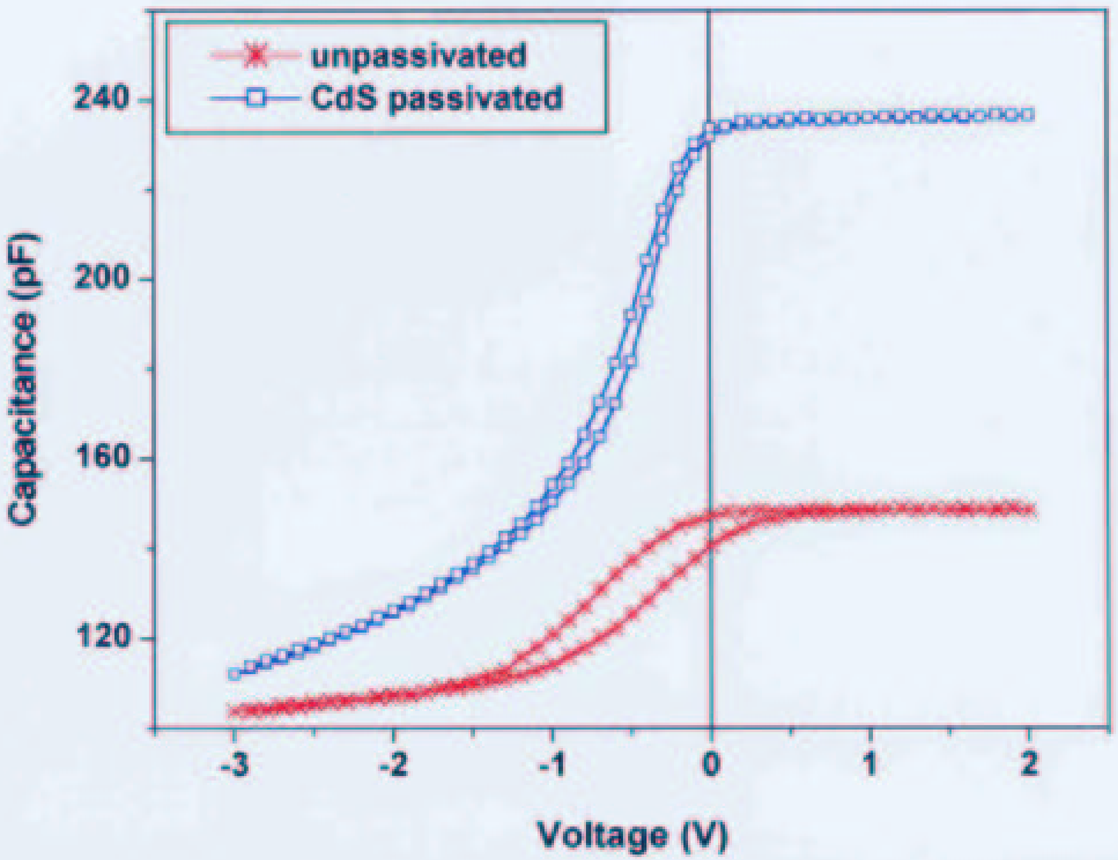
- **After passivation, the sulfur atoms in the CdS substitutes the oxygen atoms present in In_2O_3 and thereby forming In_2S_3.**

- **Thus the formation of In_2O_3 is suppressed and further this In_2S_3 is dissolvable in the electrolyte. Hence P_2O_5 formation is enhanced and formation of high resistive layer is accomplished**

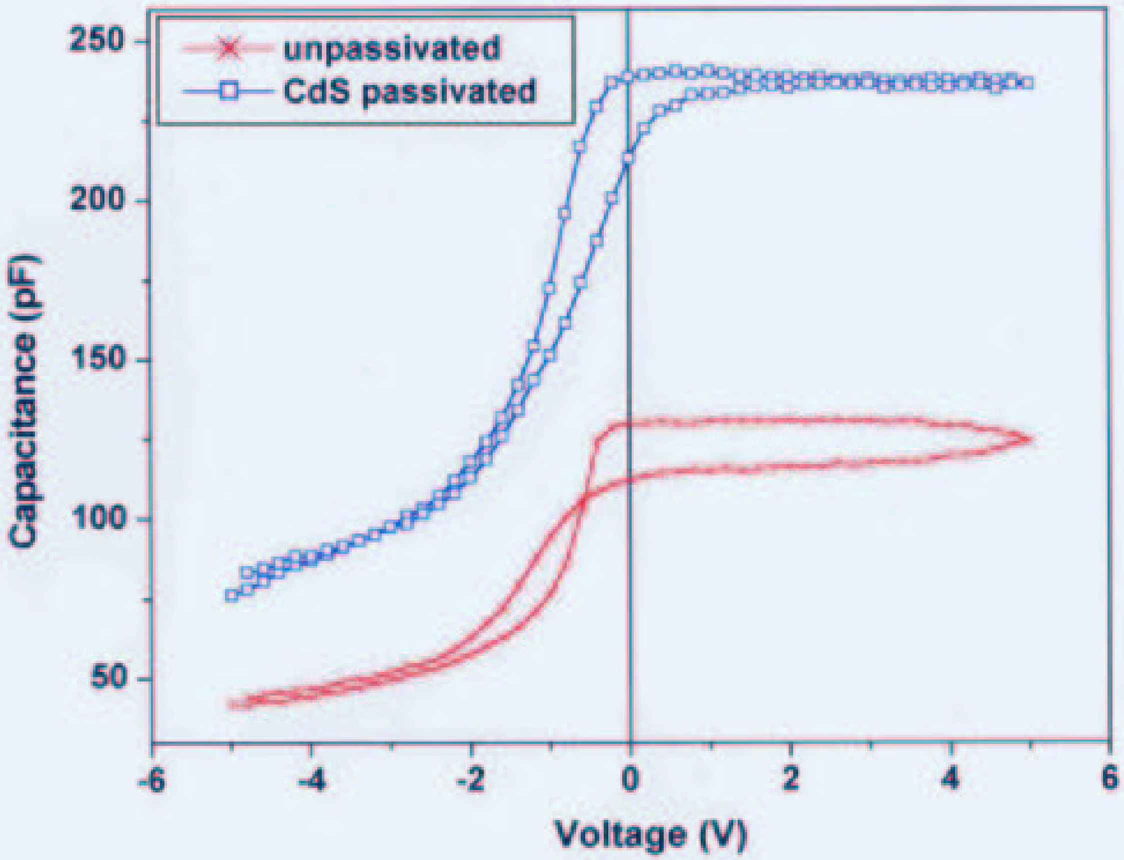


CdS passivated

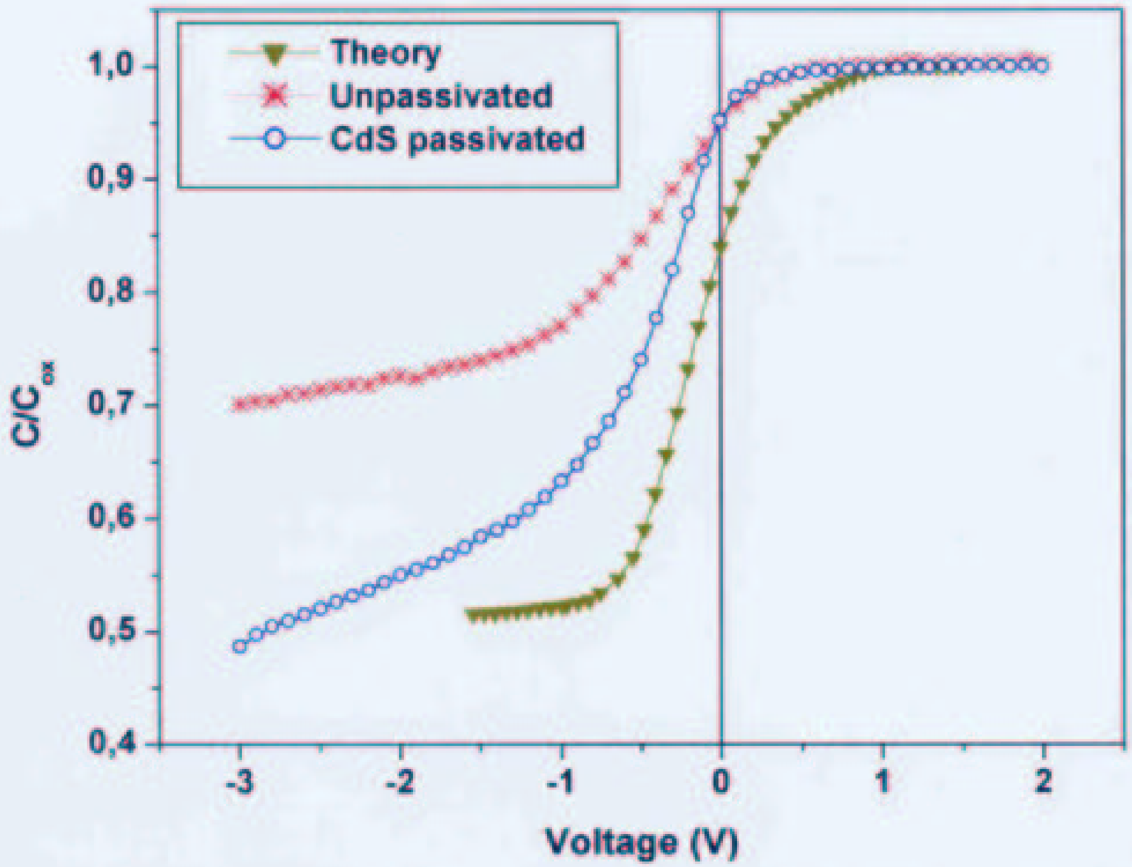
Enhanced PL intensity for BCA polished InP



1 MHz C-V curves for unpassivated and CdS passivated MIS diodes



C-V curve of the passivated sample shows the high stability even in higher bias values



For the Unpassivated In
Sample,

Nss = 6×10^{10} cm^{-2} eV^{-1} (mid gap)

4×10^{11} cm^{-2} eV^{-1} (band edge)

For passivated InP.

Nss = 10^{10} cm^{-2} eV^{-1} (throughout the band gap)

C-V curve of the passivated sample follows very good with the theoretical curve, unlike unpassivated sample

Conclusions:

- The surface states have been reduced, thereby reducing the surface Fermi-level pinning in InP by proper surface polishing and effective surface passivation processes

- A new polishing solution (BCA) has been established and it acts as a better self-passivating agent to reduce the surface states ($N_{SS} = 6 \times 10^{10}$ cm^{-2} eV^{-1})

- By CdS passivation the surface states have been further reduced ($N_{SS} = 10^{10}$ cm^{-2} eV^{-1}), thus reducing the Fermi-level pinning.

- The new polishing and passivation mechanism has been analysed and understood. The methods employed in this work are simple and very cost effective