III/V CMP Development

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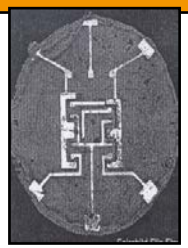
Outline

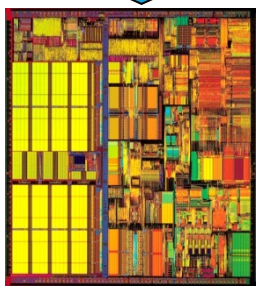
- III/V CMP background
- III/V CMP slurry formulation development at BASF
  - Basic concept development
  - Additive, component screening
  - Test on III/V patterned wafers
- Conclusion

Drivers of the electronic Industry: *Speed, Efficiency, Size and Cost*

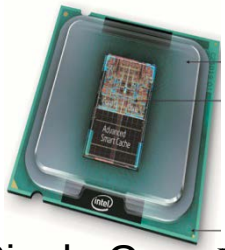
The electronic industry innovates in three dimensions:

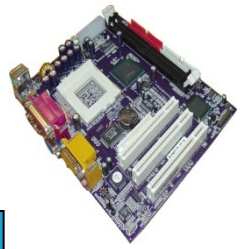
Shrinking nodes (More and smaller transistors)



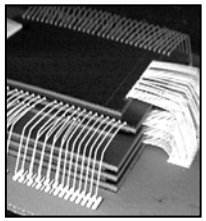


3D Architecture (Stacking/Combination)





Single Core

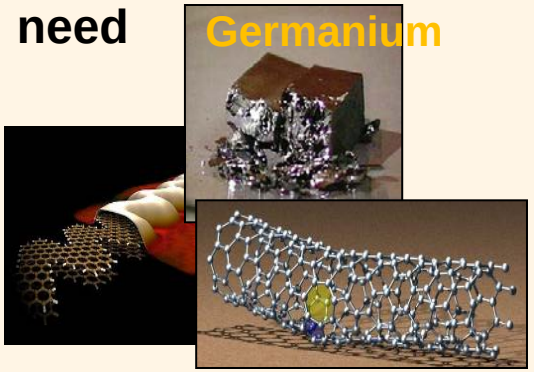


Dual Core

New Materials (eg.Ge, III/V compounds, Graphene)

- **100x faster transistors**
- **60% less energy need**

Germanium



Pictures: techspot, soccentral, INTEL, Wikipedia, Ibl

Overview III/V CMP

The introduction of high mobility materials is one of the preferred solutions to fulfill the device performance below 16nm. Ge has a very high hole mobility and is thus considered as an interesting candidate for pMOS transistors. III/V materials have very high electron mobility and thus are potential materials for nMOS transistors.(1) Chemical mechanical planarization plays a critical role to enable the integration of Ge, III/V materials, requiring good planarization performance as well as control of toxic gas release to meet EHS requirements.

Ge and InGaAs are candidates to replace Si as channel material for high-mobility devices

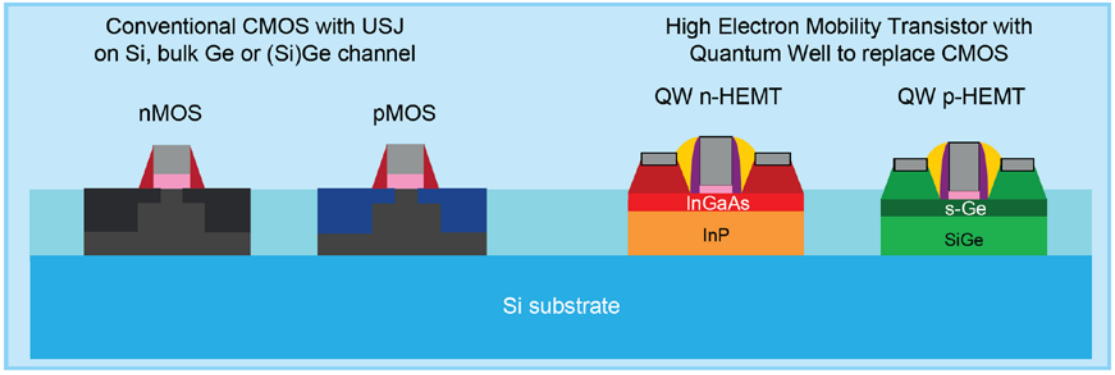


Table 1 – overview III V materials for CMP

Epi Sequence	CMP
1. InP/$In_{0.52}Al_{0.48}As$/*$In_xGa_{1-x}As$	$In_xGa_{1-x}As$
1. InP/$In_xGa_{1-x}As$	$In_xGa_{1-x}As$
1. p-InP 2. Recess + $In_xGa_{1-x}As$	InP $In_xGa_{1-x}As$
1. InP 2. Recess + $In_{0.52}Al_{0.48}As$ 3. Recess + $In_xGa_{1-x}As$	InP $In_{0.52}Al_{0.48}As$ $In_xGa_{1-x}As$

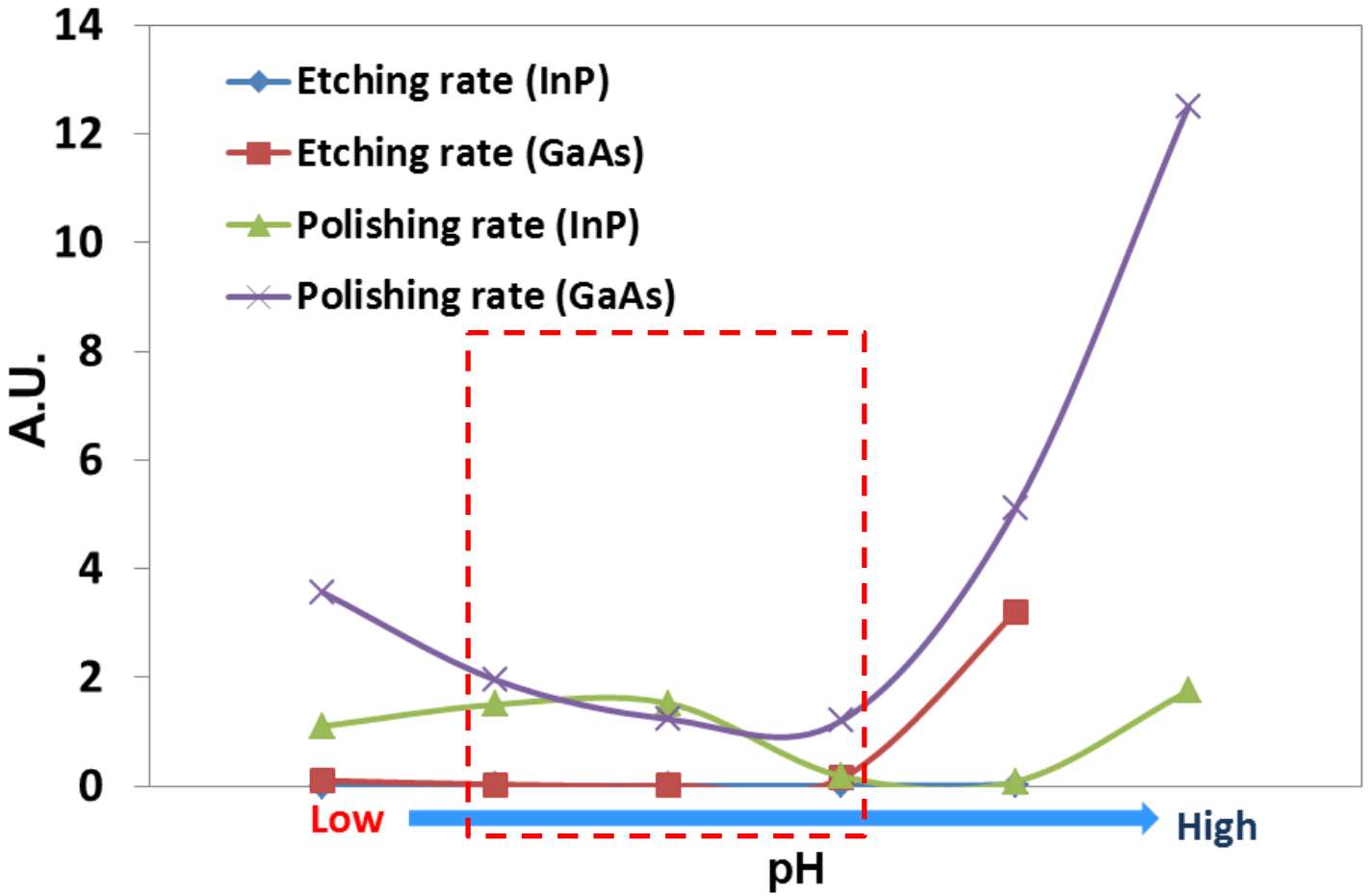
*$In_xGa_{1-x}As$ – x:0.53-1

Possible need for InP, $In_xGa_{1-x}As$ and $In_{0.52}Al_{0.48}As$ CMP processes

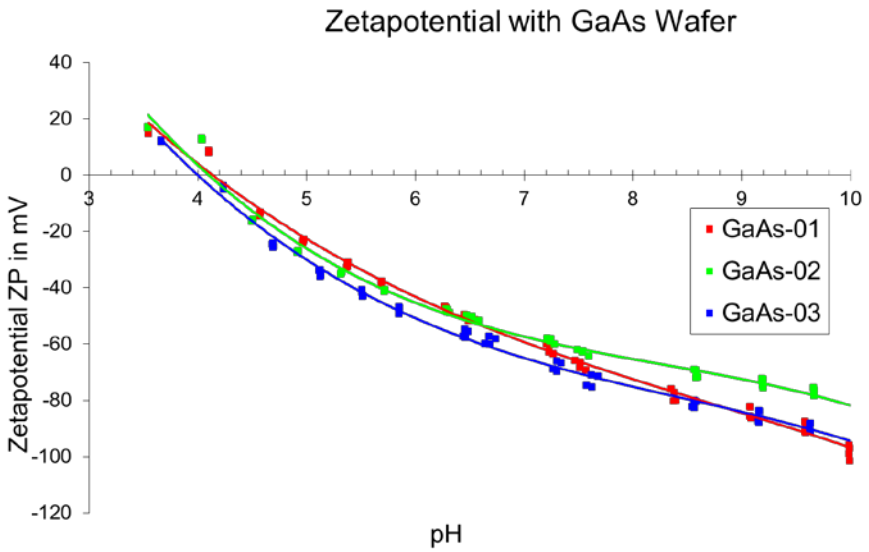
References:

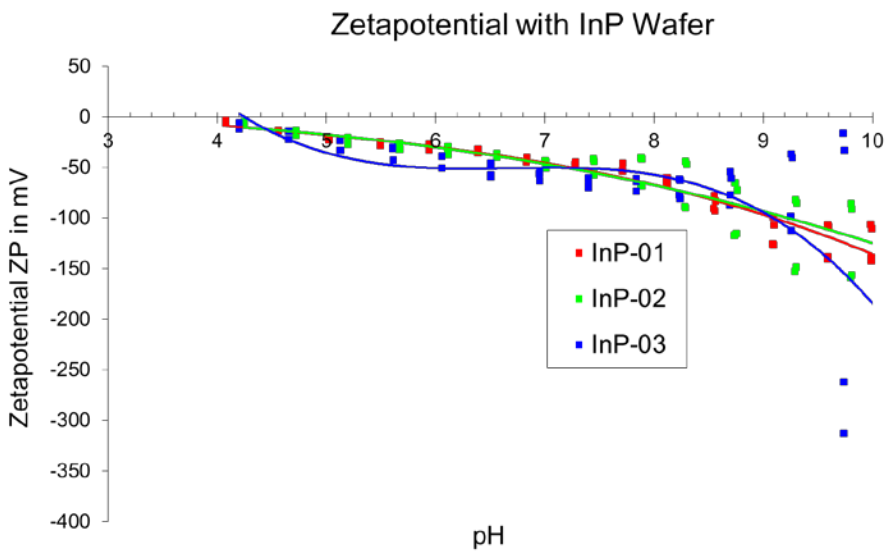
(1) Patrick Ong, Liesbeth Witters, Niamh Waldron and L.H.A. Leunissen, ECS Trans. 2011 volume 34, issue 1, 647-652

How did We Identify the Mechanism in III/V (GaAs, InP) CMP



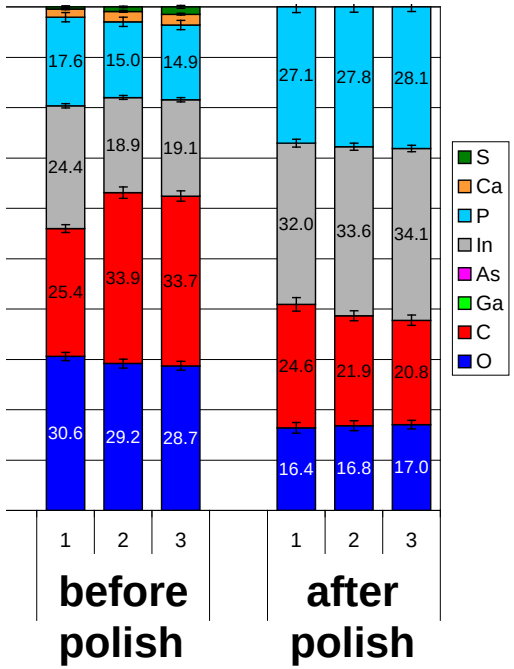
Zeta Potential of III/V Substrates

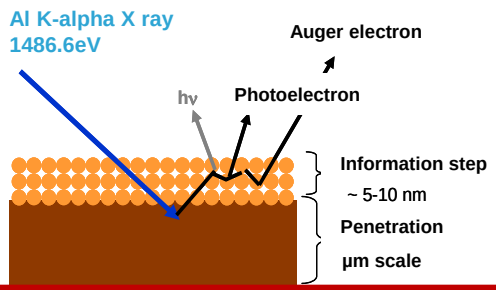




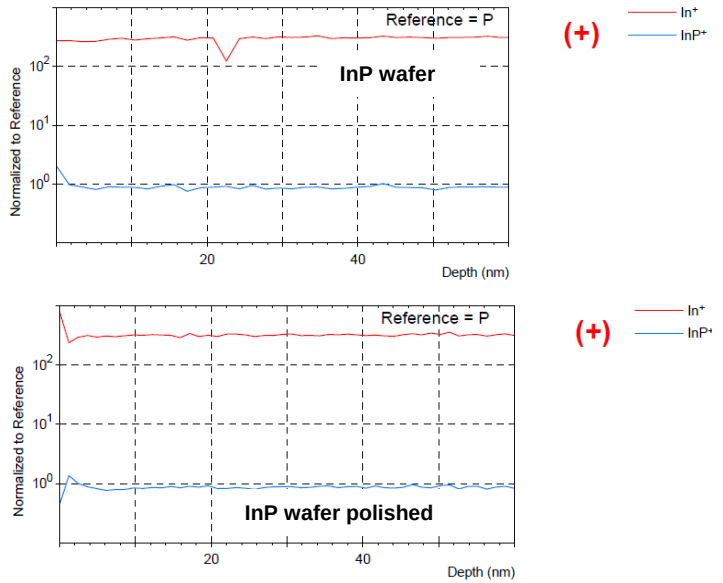
III/V-InP Surface Analysis

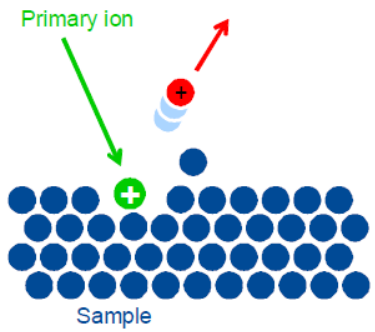
XPS





TOF-SIMS





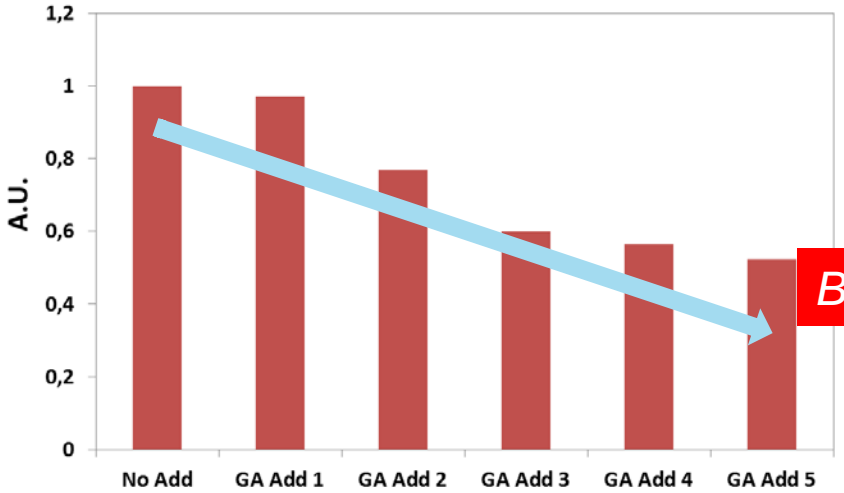
Analysis Parameters:

PI:	Bi1
Energy:	25 keV
Current:	1.000 pA
Area:	250 x 250 µm²
PIDD:	4.91E+012 Ions/cm²

III/V CMP Performance Improvement
Passivation v.s Activation

BASF
The Chemical Company

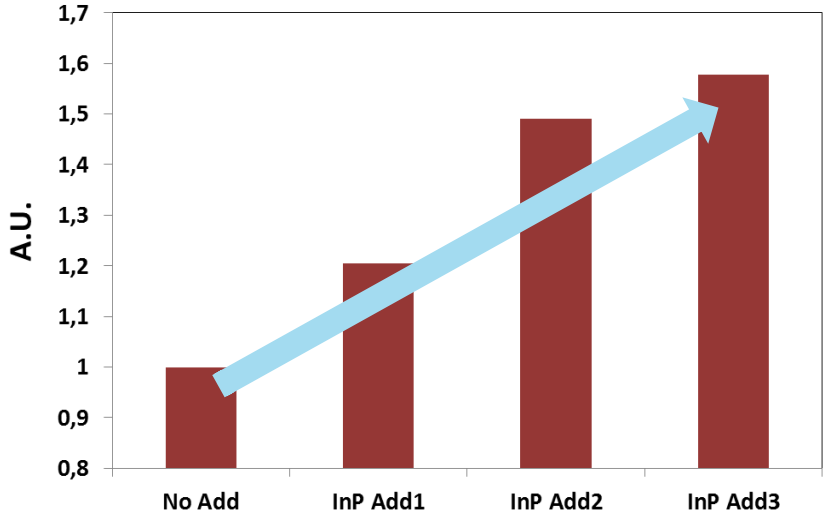
GaAs



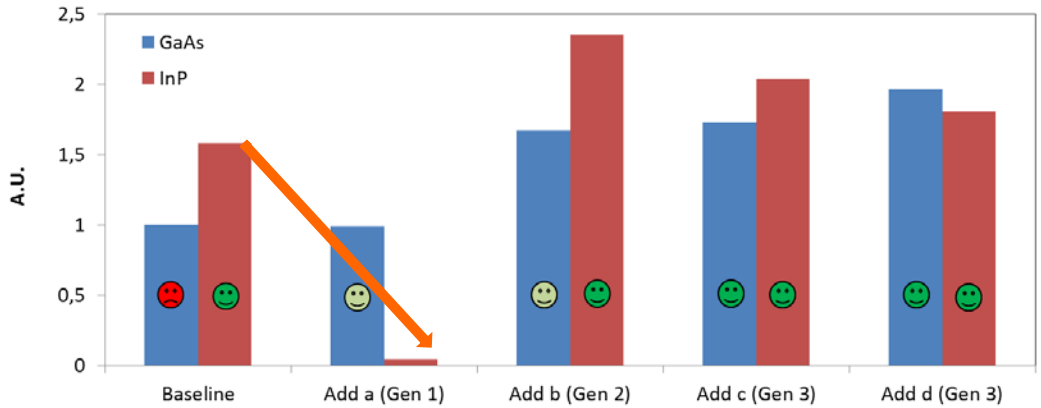
Baseline

With additive

InP



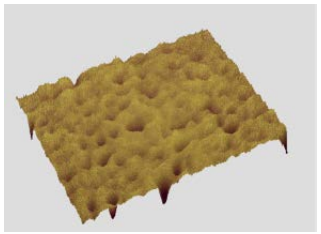
A Balance of Polishing Rate and Surface Finish in III/V CMP



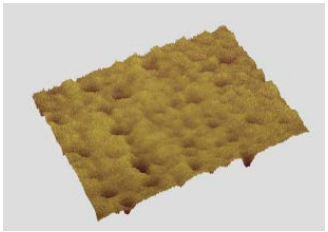
Surfacequality(visure check):

- very good
- nice
- bad

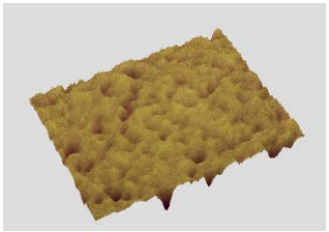
GaAs Surface Finish (White light interferometry)



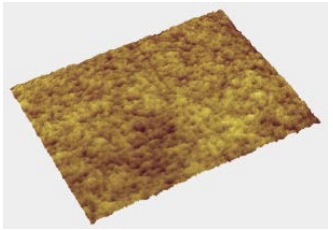
Baseline: RMS>0.8nm



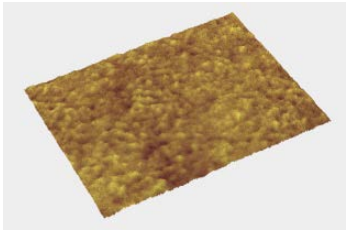
Add a(Gen1): RMS>0.8nm



Add b(Gen 2): RMS>0.8nm

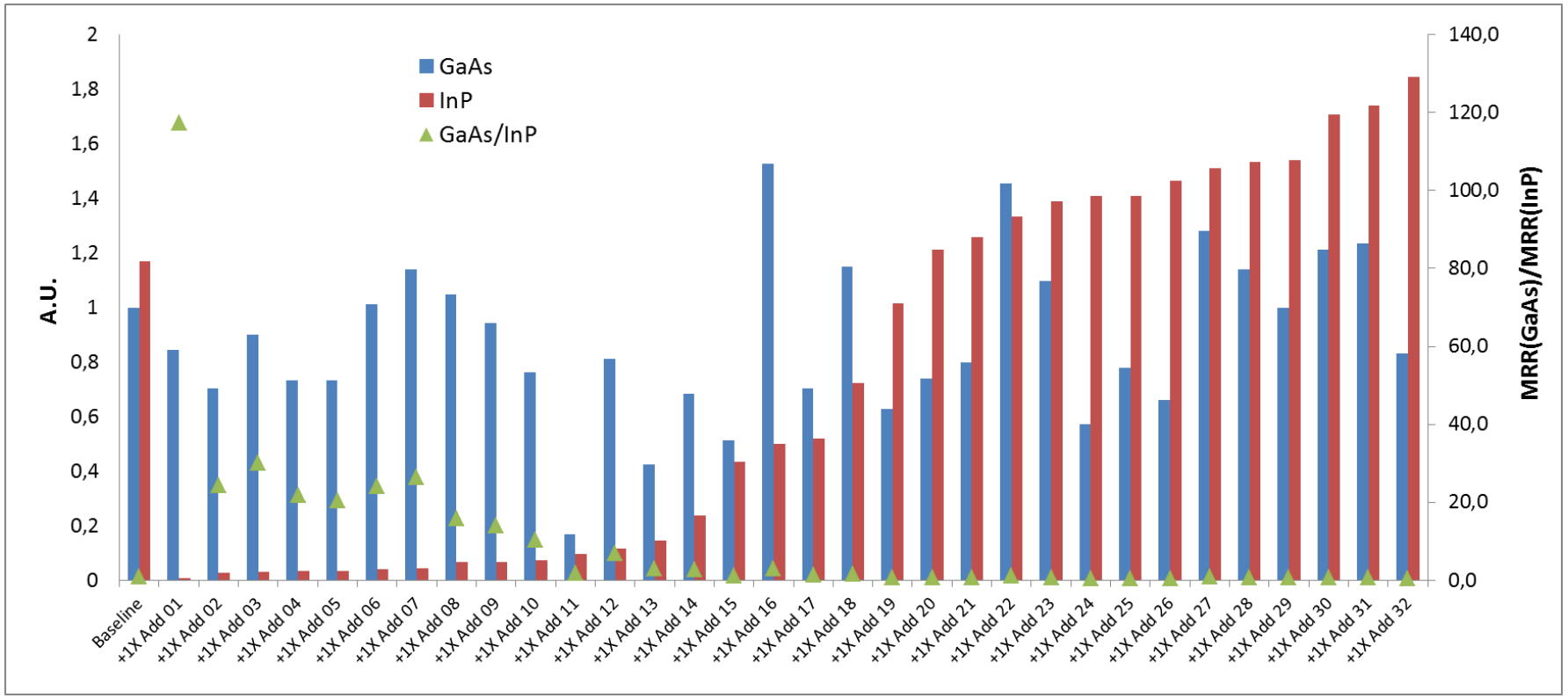


Add c(Gen3): RMS<0.5nm

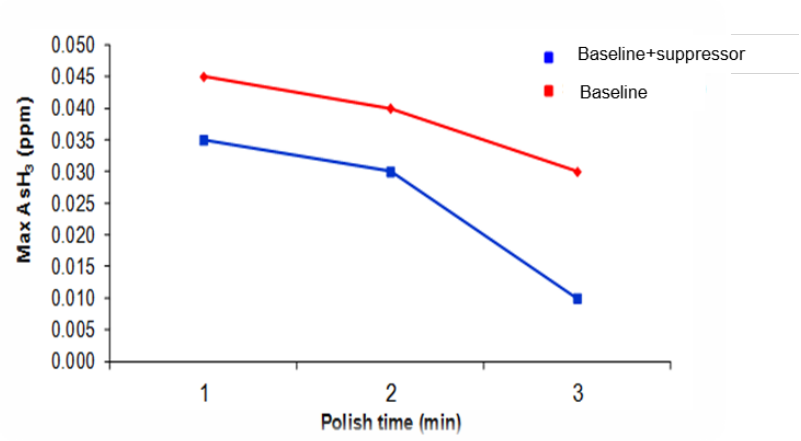


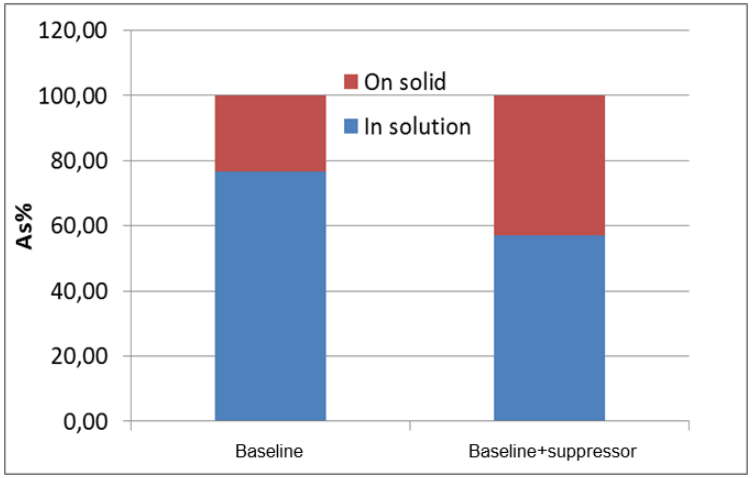
Add d(Gen3): RMS<0.5nm

BASF Additives Enable a Broad Range of Selectivity in III/V CMP



Gas Releasing Control in III/V CMP



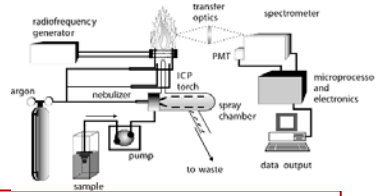


Waste slurry

Centrifugate: remove abrasives

Top solution

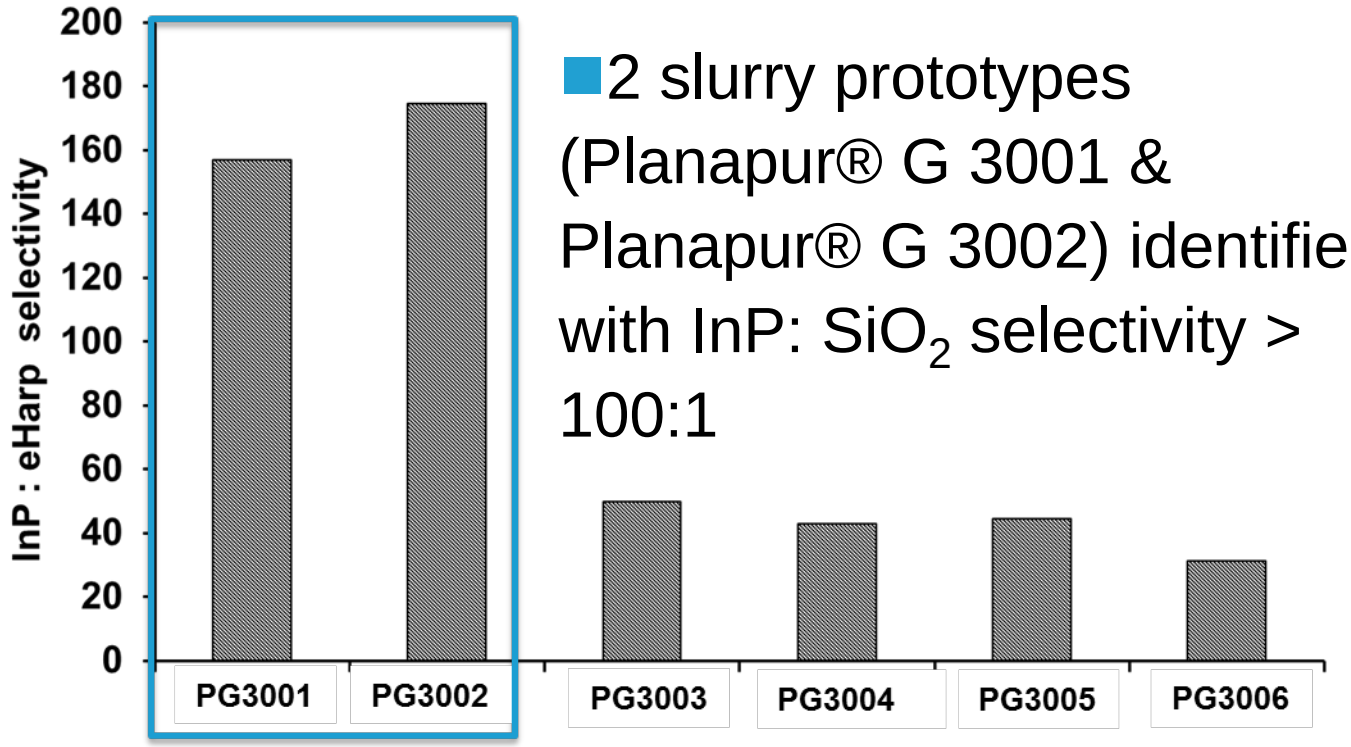
Dissolve abrasives



Complete waste slurry

Inductively coupled plasma atomic emission spectrometry (ICP-AES)

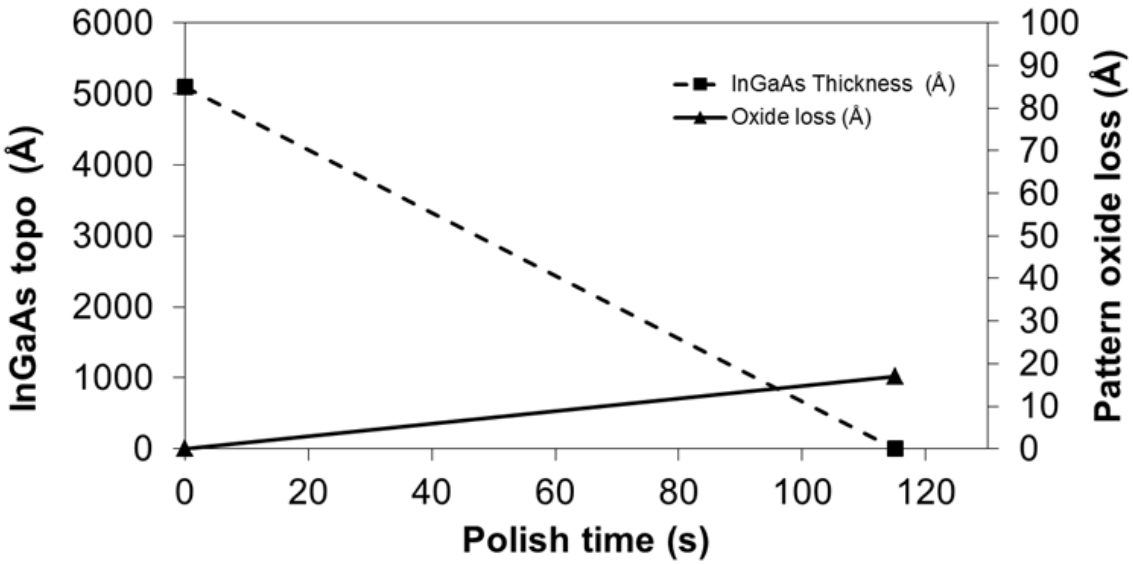
Selectivity on Oxide Layer



- 2 slurry prototypes (Planapur® G 3001 & Planapur® G 3002) identified with InP: SiO_2 selectivity > 100:1

300mm Patterned Wafer Study: InGaAs STI with Planapur® G 3002

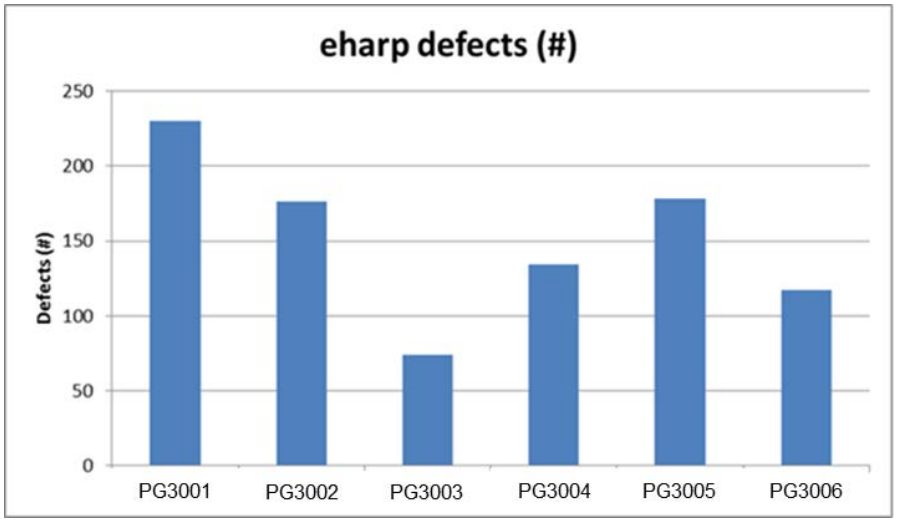
- ***Planarization achieved with about 110sec CMP***
- ***Oxide loss < 20A in 110 sec polishing***



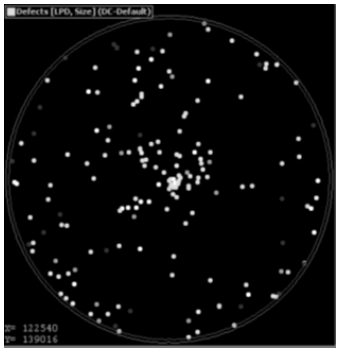
InGaAs – POST CMP

- ***Low dishing (<50A)***
- ***Low erosion (<50A)***

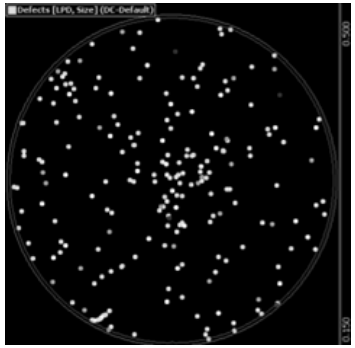
Defects on eharp Oixde



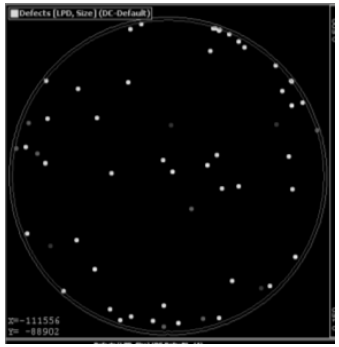
- Slurry formulation showed strong impact on defects performance on oxide substrates
- Correlation study ongoing: defects on oxide, defects on III/V



PG 3001
EHARP – 176 @0.15um



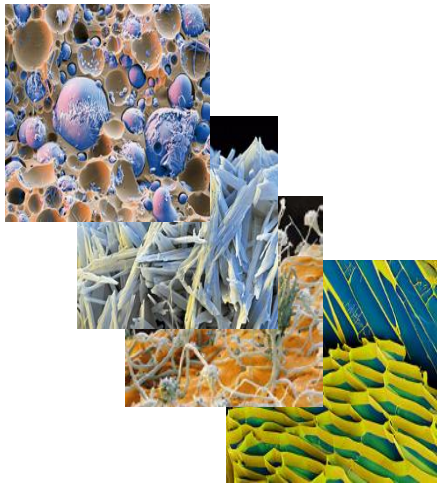
PG 3002
EHARP – 230 @0.15um

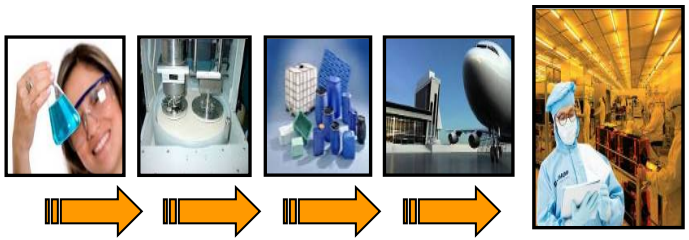


PG 3003
EHARP – 74 @0.15um

BASF has Strong Chemical Know-how in-house to Develop CMP Slurries

BASF Chemical Toolbox → **CMP Formulation** → **Customer Samples**





→ ***Fast R&D samples***

End Customer

- **Complexing Agents**
- **Inhibitors**
- **Oxidizers**
- **Abrasives**
- **Polymers**

Conclusions

- **III/V materials polishing models are developed based on substrate analysis and polishing experiments**
- **BASF additives provide a broad window for selectivity and surface finish tuning in III/V CMP**
- **III/V patterned wafer (300mm) test confirmed high planarization, low erosion, dishing with BASF formulations**
- **Methodology under development for more detailed defects study on III/V materials**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