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Modelling investigations of surface photovoltage including surface defects

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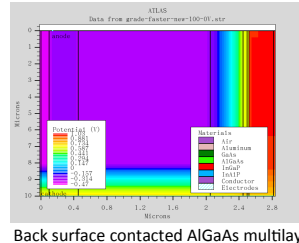
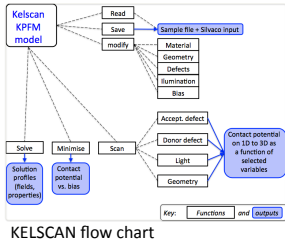
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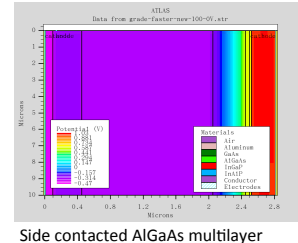
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KPFM principles : see "Local probe microscopies for the study of III-V based solar cells", Mattia da Lisca et al., in this visual presentation session

KPFM - issues : Affinity, doping work function: BULK properties. Solution : Numerical modelling => KELSCAN modeling package (IPVF/GeePs)
KPFM is SURFACE technique Including geometry, surface defects, characterisation techniques



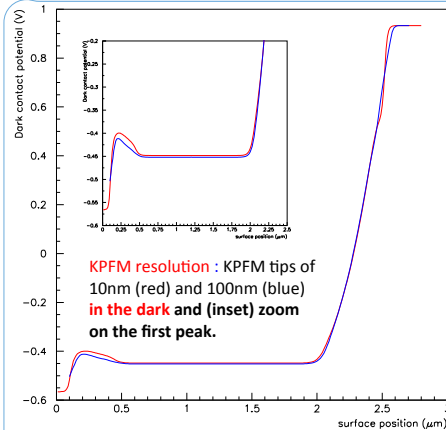
Back surface contacted AlGaAs multilayer



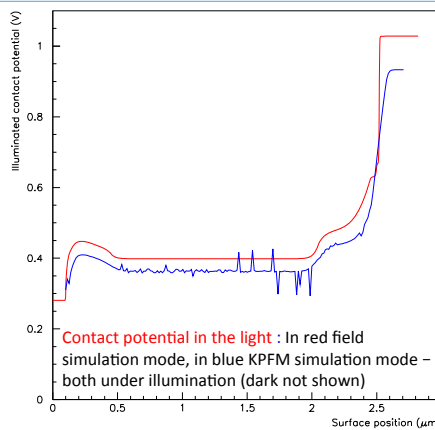
Side contacted AlGaAs multilayer

Simulation methods : (1) KPFM experiment mode : Simulation of the KPFM tip, numerical field minimisation point by point
(2) Field simulation mode : Numerical transport drift diffusion directly yields surface potential

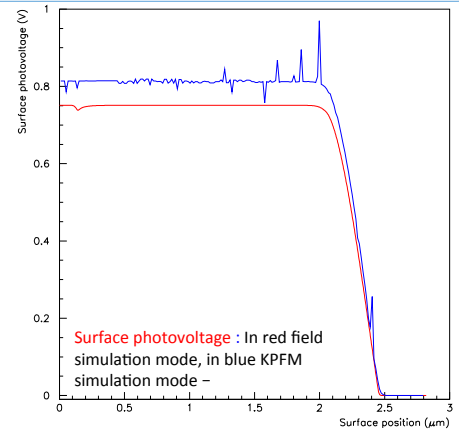
Simulation options: Arbitrary illumination Field profiles on four surfaces - KPFM scanning on top section
Contacts on sides and / or back, kpfm tip on top section, option to remove contacts / tip



KPFM resolution : KPFM tips of 10nm (red) and 100nm (blue) in the dark and (inset) zoom on the first peak.



Contact potential in the light : In red field simulation mode, in blue KPFM simulation mode - both under illumination (dark not shown)

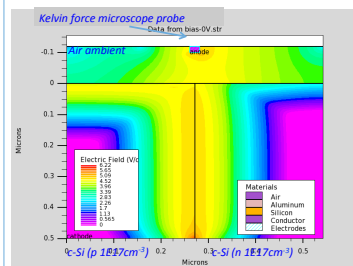


Surface photovoltage : In red field simulation mode, in blue KPFM simulation mode -

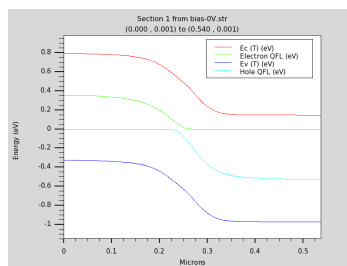
Evaluation of KPFM resolution : Weak dependence for two tip dimensions shown here in the dark

Simulation method : Full KPFM simulation is noisy in the light and subject to an offset due to contact issues to be investigated

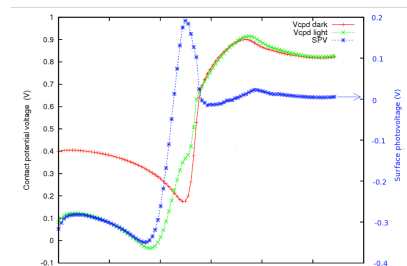
pn junctions in the light with defective surfaces



Donor defects ND(peak) = 1e18/cm³(eV)
Depletion mainly p-side (n-side doping gradient junction)



Bands and populations for donor defects



Light, dark KPFM scans, and SPV: p-side QFL splitting due to the p-type surface defect layer.

Sample : c-Si : [p-1E17cm⁻³ 0.27μm][n-1E17cm⁻³ 0.27μm] - Defect layer 0.1μm thick - Illumination 0.5μm monochromatic, 1000W/m²

Discussion:

- Resolution : Simulation decouples transport issues inherently limiting resolution from KPFM tip influences.
- Simulation methods: Simulation of experiment required to validate resolution. Direct solution far more efficient if possible.
- Surface defects : Modification of potential CPD profiles due to surface defects can be simulated
Challenge : knowledge of surface defect properties.
- In progress : Modulated spectrally resolved SPV

To be detailed in a follow-up JNPV publication in EPJ PV : Modification and explanation of CPD and SPV profiles due to defects