

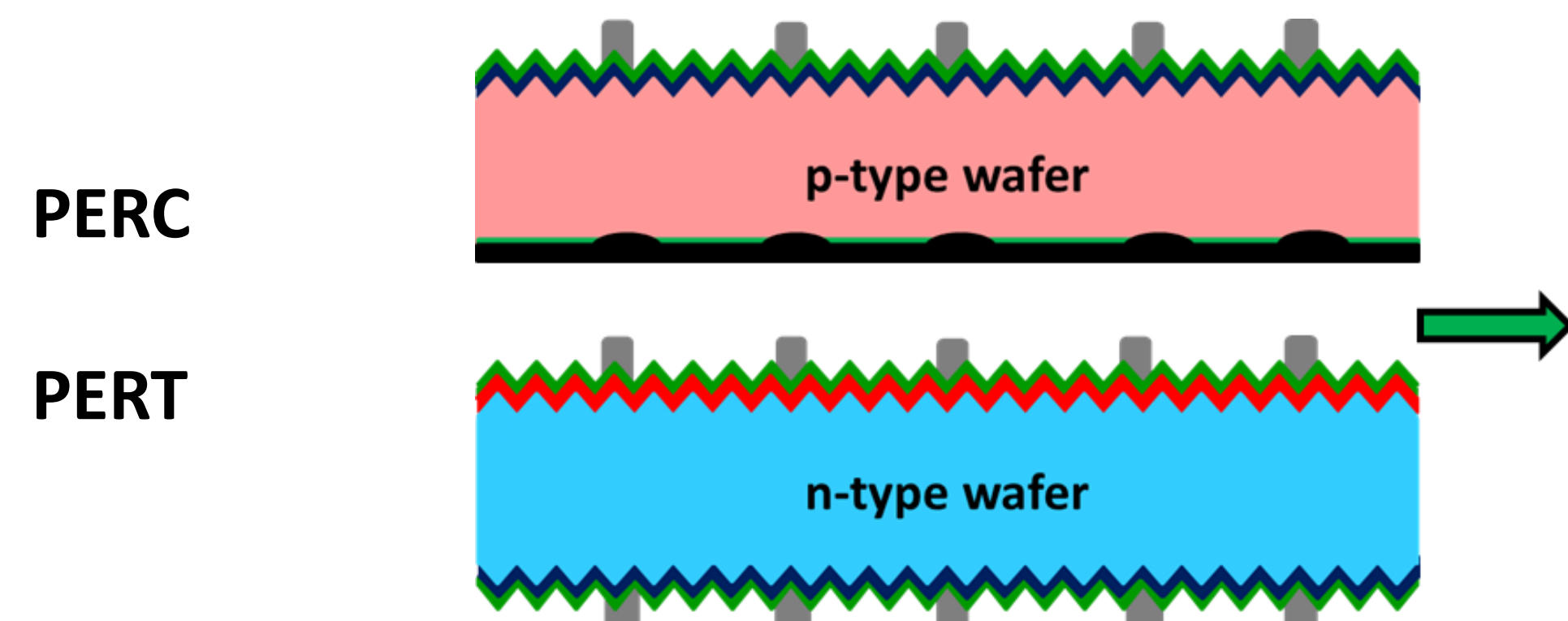
Miracle: wafer type independent device; 1st results

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the concept

- 23% cell, process for both n- and p-type Cz wafer
- phosphor-diffused and SiN passivated front side
- p⁺-poly passivated rear side
- screen printed metallization



the benefits

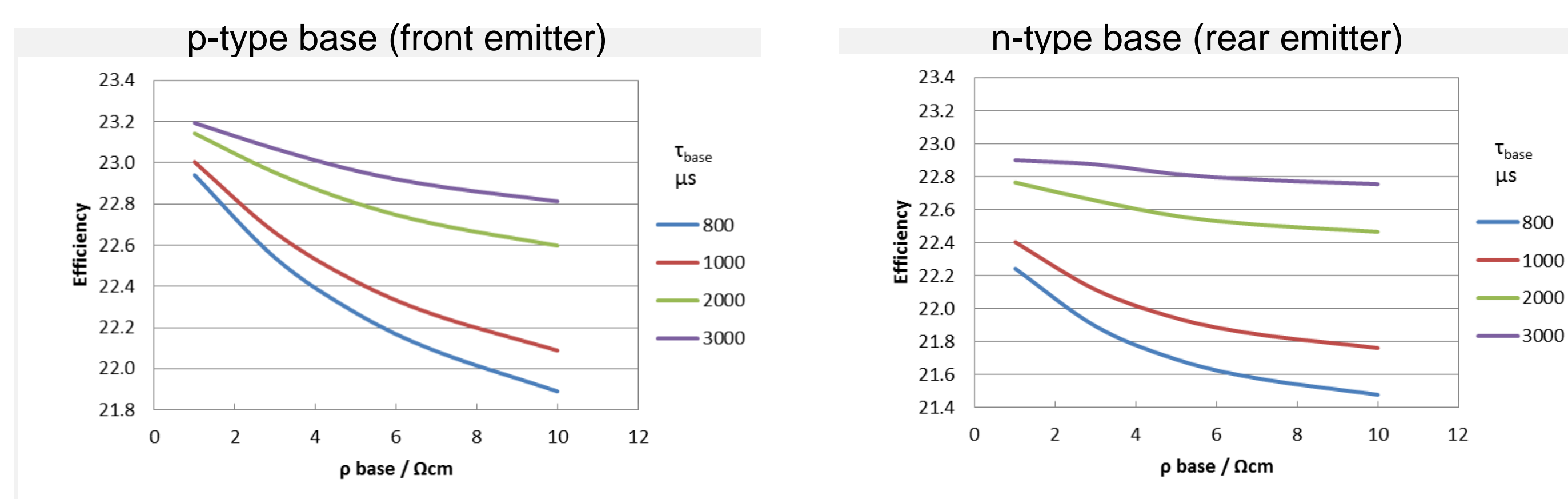
- stepwise upgrade to new technology chain
- starting point for further future technologies
- TRL level 4-5

material independent
Miracle

the challenge

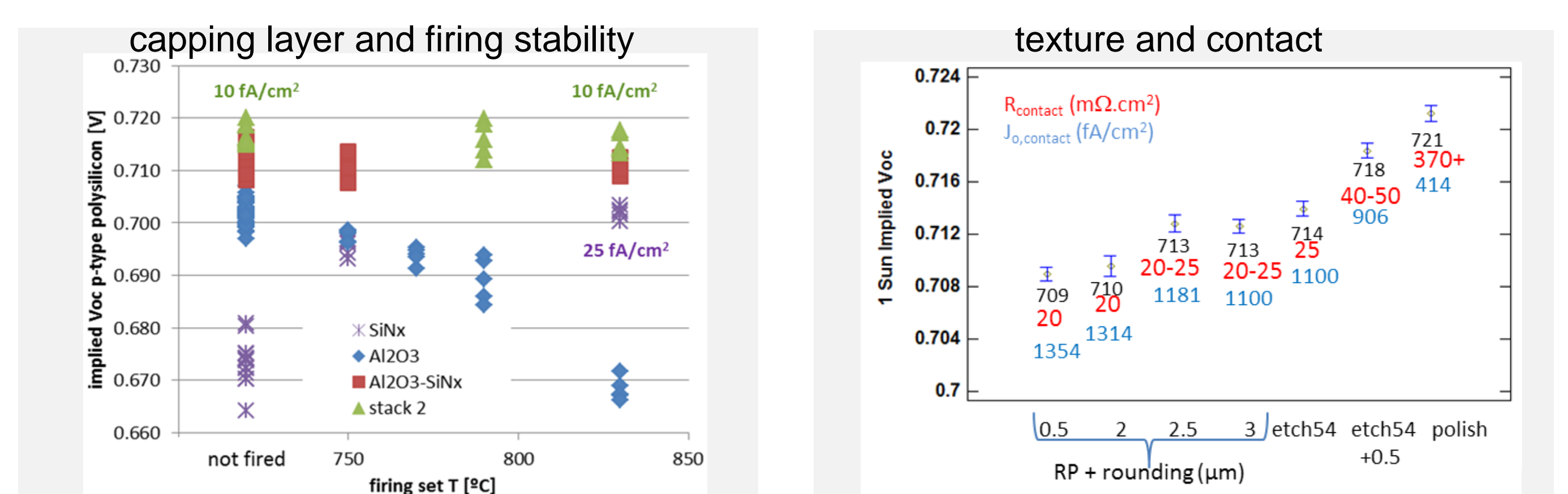
to achieve 23% cell with textured surface:

- J_0 p⁺-poly : 10 fA/cm² (state-of-the art: 15-35 fA/cm²)
- J_0 p⁺-contact : 10 fA/cm² (state-of-the art: 100-500 fA/cm²)
- R_{contact} : 1 mΩ.cm² (state of the art: 5-15 mΩ.cm²)



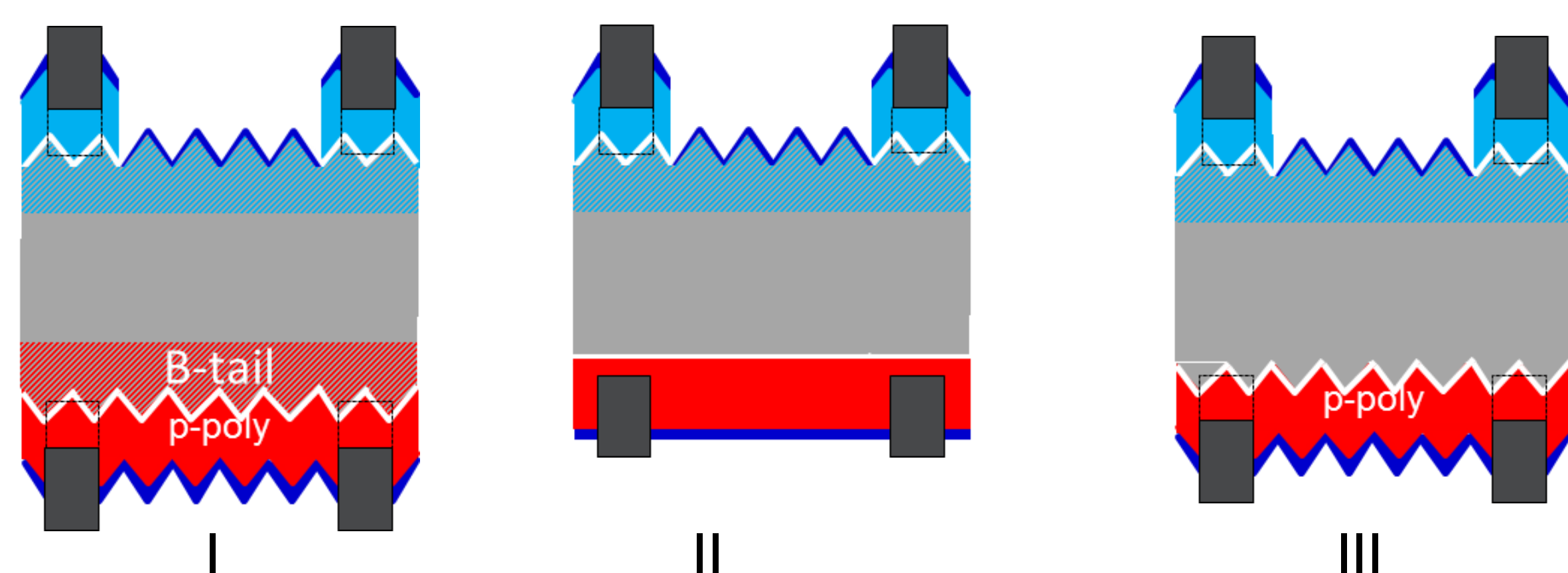
p⁺ poly passivation (capping and texture)

- on RP texture with dedicated capping:
 - J_0 10 fA/cm²; iVoc 720 mV (firing firing stable)
- on modified texture with AlOx / SiN capping
 - J_0 12 fA/cm²; iVoc 718 mV



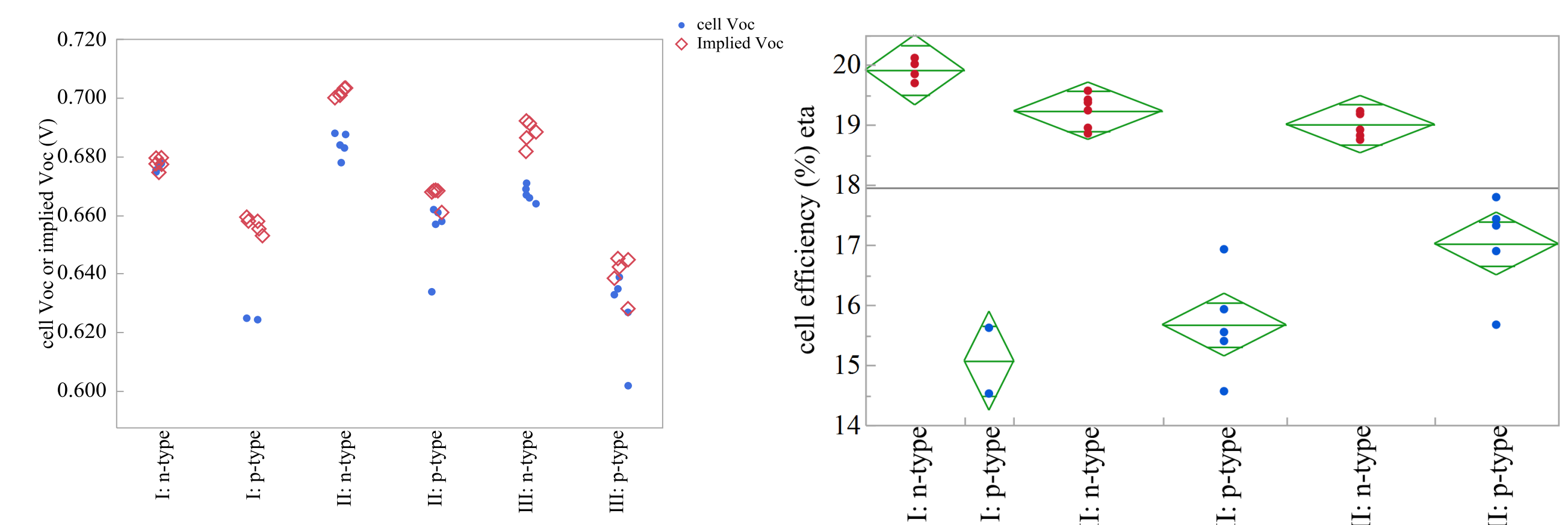
1st Miracle cell experiment; DoE

- both p-type and n-type Cz wafers ($\rho \sim 3\Omega\cdot\text{cm}$)
- 125 ohm/sq POCl₃ front diffusion; BBr₃-doped p⁺-poly rear
- polished and random pyramids rear
- screen printed metal (front selective n⁺-poly contact passivation)



1st Miracle cell experiment: results

- truly passivating contact in A: n-type? (iVoc-Voc < 2mV) at 680 mV
- highest Voc: **n-type: 688 mV / p-type: 662 mV** (for polished rear side)
- best cell efficiency: **n-type: 20.1%** / p-type: 17.8%
- Jsc / FF limiting; additional for p-type: bulk degradation by processing



outlook

excellent starting point for future developments:

- J_0 p⁺-poly on texture: 10 fA/cm² (test structure)
- Voc 688 mV / 662 mV (n/p) (cell)
- 20.1% without any cell optimization (cell)
- next step combine capping and texture also in cell
- efficiency 20% limited by FF; next step contact optimization

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