



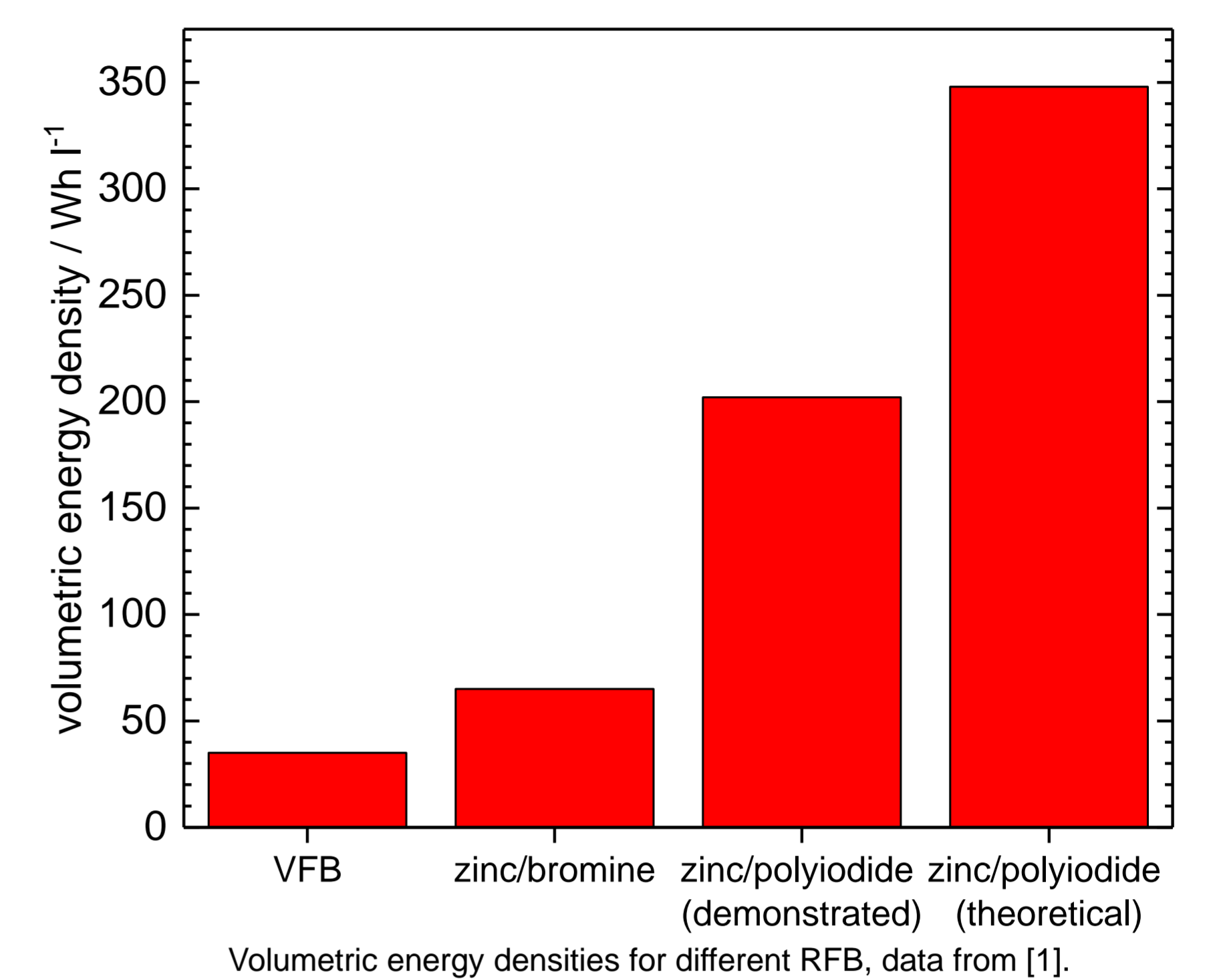
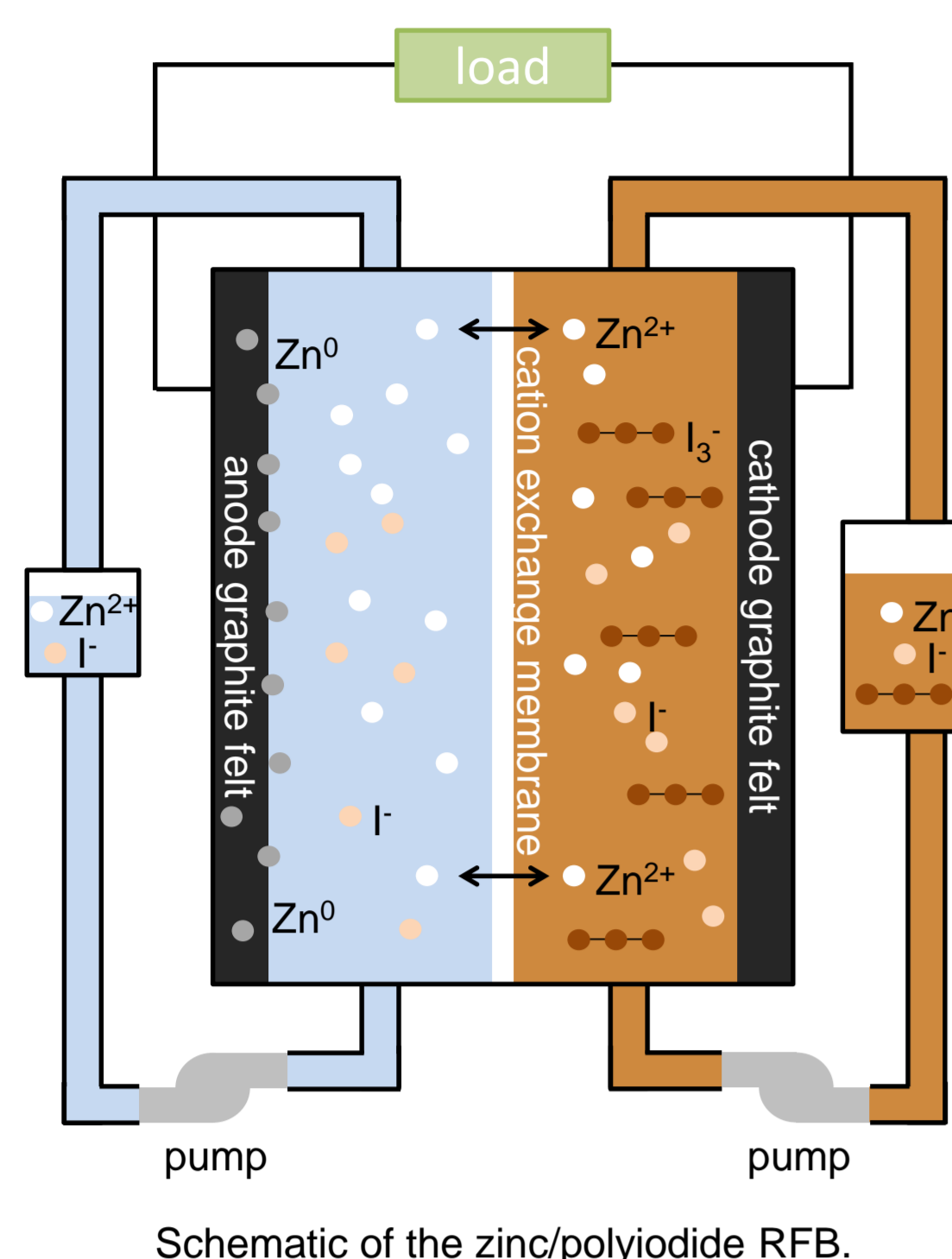
Comparison of flow fields with CFD simulations and electrochemical experiments within a 250 cm² zinc/polyiodide RFB

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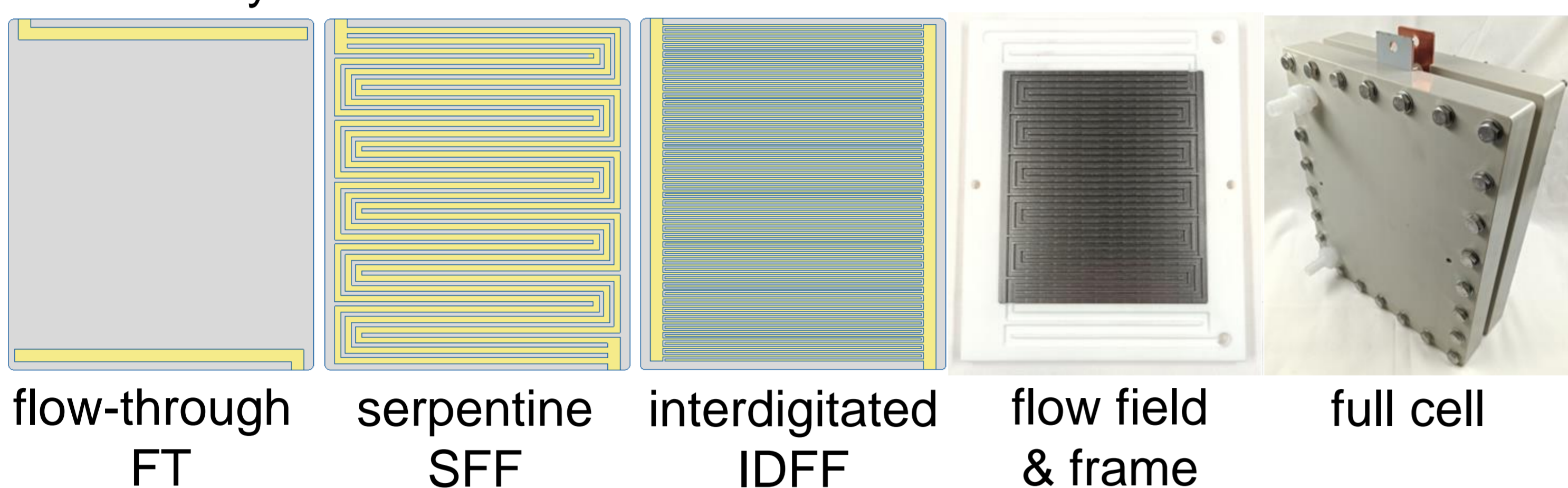
Advantages of zinc/polyiodide redox flow batteries

- electrolyte: aqueous ZnI₂ solution contains both active species
- ZnI₂ is soluble up to at least 5 mol l⁻¹
- Zn²⁺ as charge carrier, diffuses through membrane
 - no additional acid/base or salt necessary
 - anolyte volume can be kept small
- 2 electrons transferred per redox process
 - up to 10 times higher volumetric energy density compared to VFB



250 cm² cell

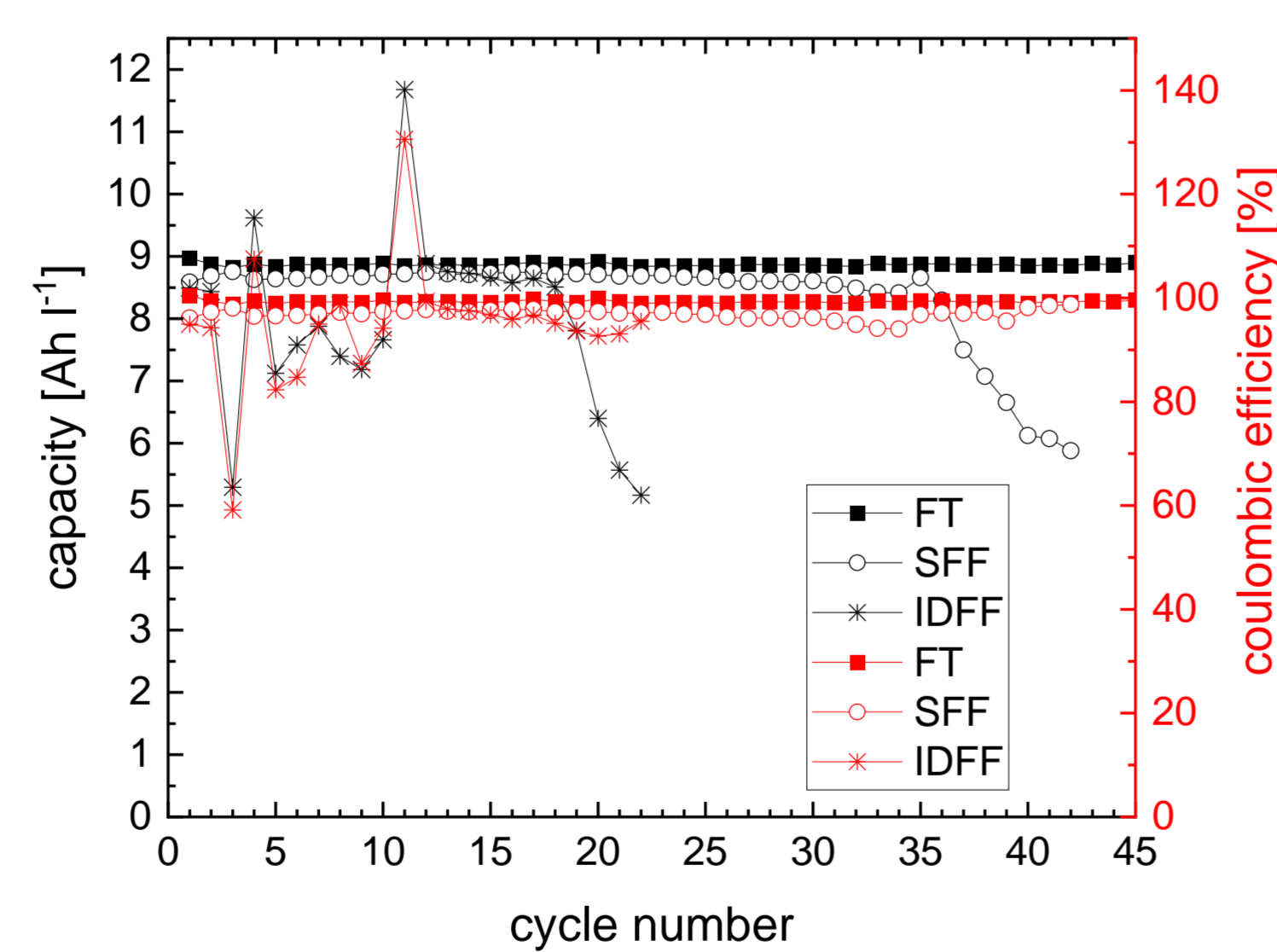
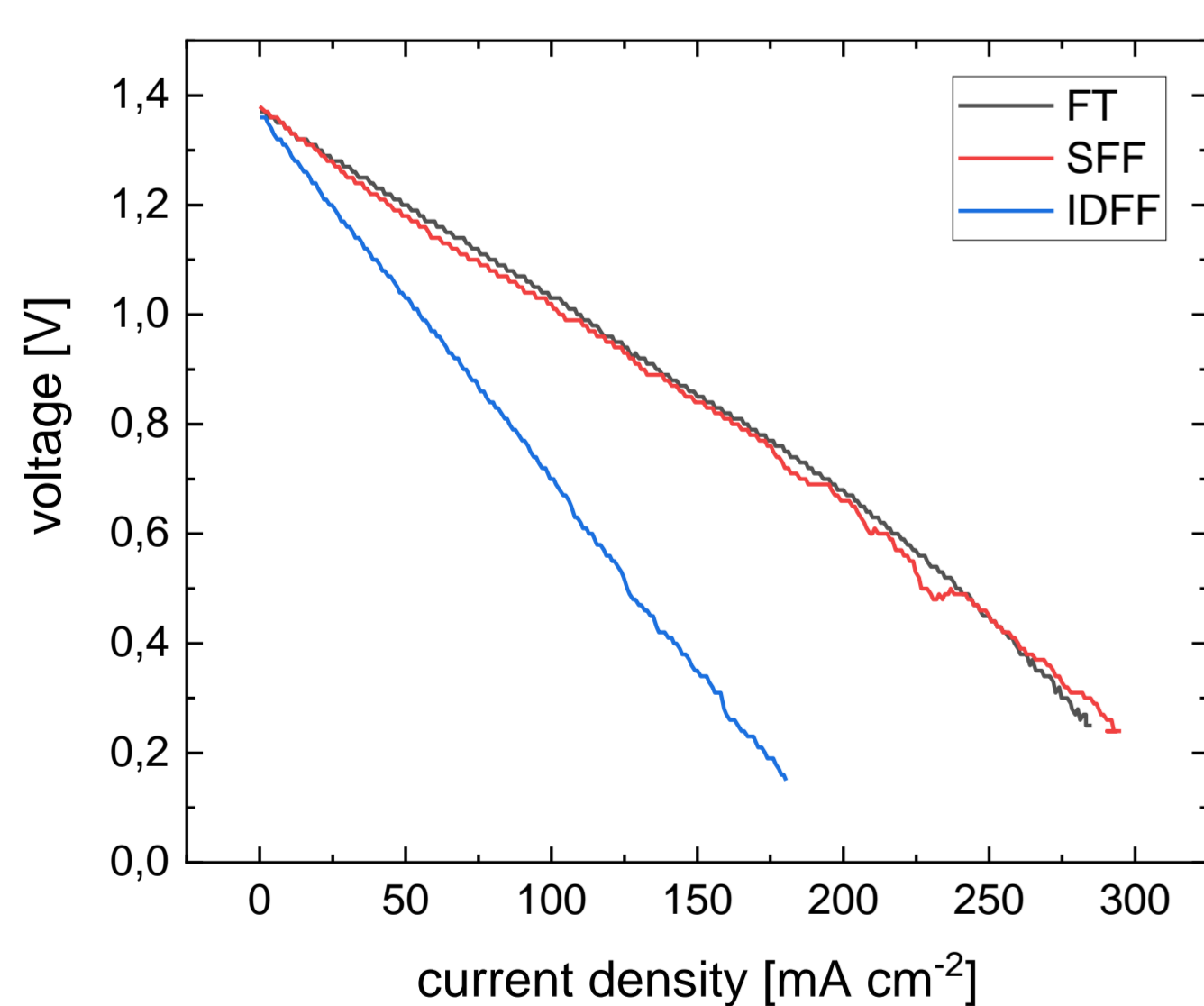
- 3 different flow field plates fabricated, after 11 simulated
- basis for a ten-cell stack
- additional serpentine in flow frames in order to minimize shunt currents
- electrolyte distribution within flow frames



Experimental results

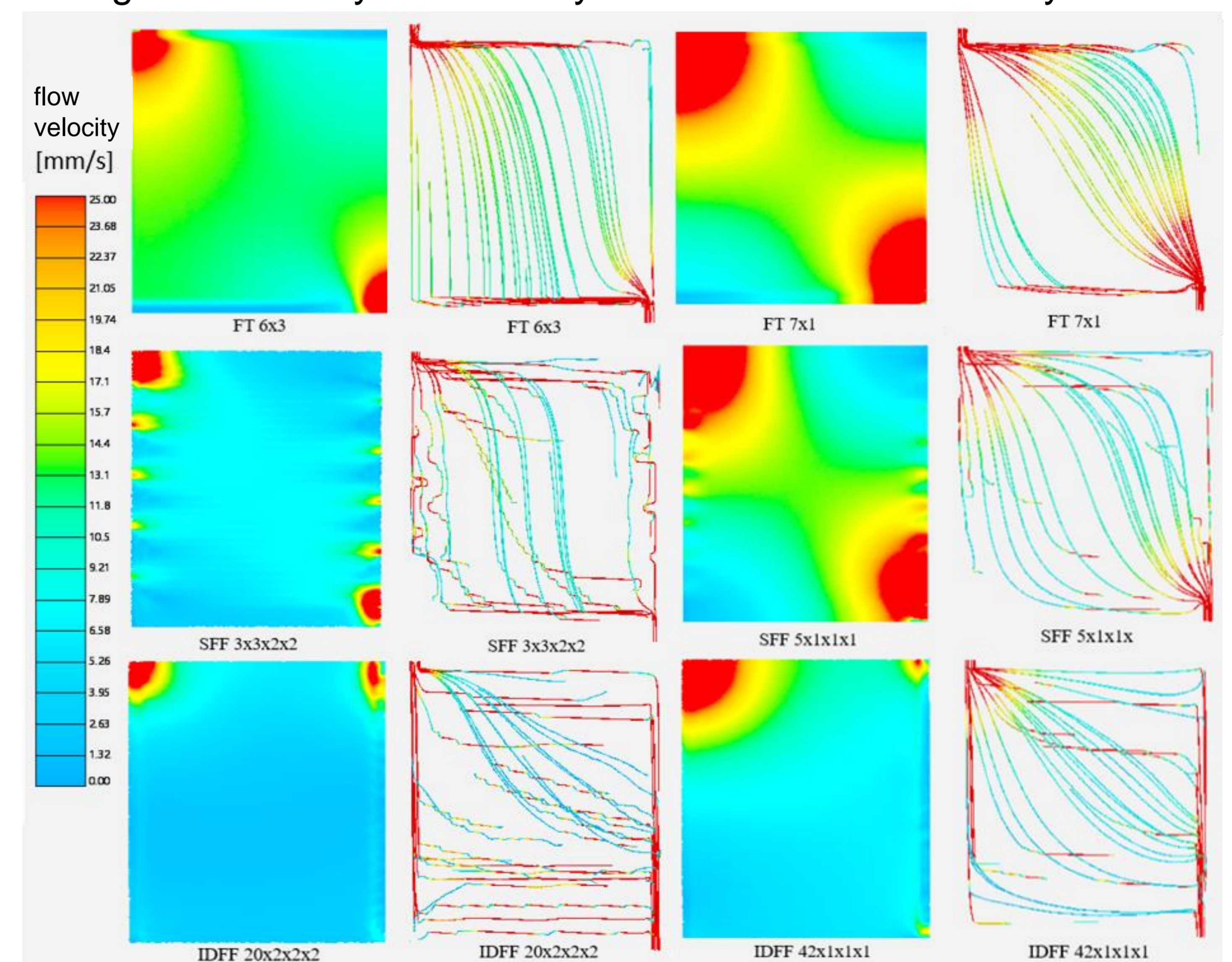
- graphite felts fabricated and activated by Mersen
- Nafion NR-212 membrane (pristine)
- electrolyte: 0.5 M ZnI₂ + 0.25 M ZnBr₂ [2] + 2 M NH₄Cl
- current-voltage-curves: 2 mA cm⁻² s⁻¹
- charge discharge cyclisation experiments: 50 mA cm⁻²
- ohmic resistances from impedance spectroscopy

flow field	ohmic resistance	cycle number	avg. coulombic eff.
FT	12.5 mΩ	> 45	99.3 %
SFF	12.5 mΩ	32	96.7 %
IDFF	18.4 mΩ	18	94.9 %



CFD simulations

- combinations of flow field and graphite felt
- initial felt thickness: 4.5 mm, compression rate: 25 %
- flow velocities directly at the membrane shown below
- “streamlines”: potential pathways within flow field and felt
- inlets: bottom right, outlets: top left
- nomenclature: parallel channels x channel width x channel depth x rib width in mm
- avg. flow velocity = uniformity factor x max. flow velocity



flow field	pressure loss	uniformity factor
FT 6x3	3105 Pa	0.178
FT 7x1	5469 Pa	0.068
SFF 3x3x2x2	3030 Pa	0.098
SFF 5x1x1x1	6515 Pa	0.073
IDFF 20x2x2x2	2738 Pa	0.056
IDFF 42x1x1x1	5654 Pa	0.078

chosen for fabrication, only depicted as FT, SFF and IDFF in experimental results

Conclusions

- only small zones of low flow velocity in top right and bottom left corners for FT 6x3 and SFF 3x3x2x2
- large zone in bottom left corner for IDFF 42x1x1x1, generally low velocities for IDFF 20x2x2x2
- streamlines show unwanted, diagonal electrolyte flow for FT 7x1 and SFF 5x1x1x1, but also IDFF 42x1x1x1
- practically identical ohmic resistances and current-voltage-curves for fabricated FT and SFF, much worse for IDFF
- reached cycle number and avg. coulombic efficiency dependent on uniformity factor: FT > SFF > IDFF
- more sophisticated flow field needed in order to surpass FT and reach even higher current densities and cyclability

Literature

- [1] B. Li et al., Ambipolar zinc-polyiodide electrolyte for a high-energy density aqueous redox flow battery, *Nature Communications*, 2015.
[2] G.-M. Weng et al., Unlocking the capacity of iodide for high-energy density zinc/polyiodide and lithium/polyiodide redox flow batteries, *Energy & Environmental Science*, 2017.