Scaled Up Synthesis of Platinum-Nanowires using Microfluidics

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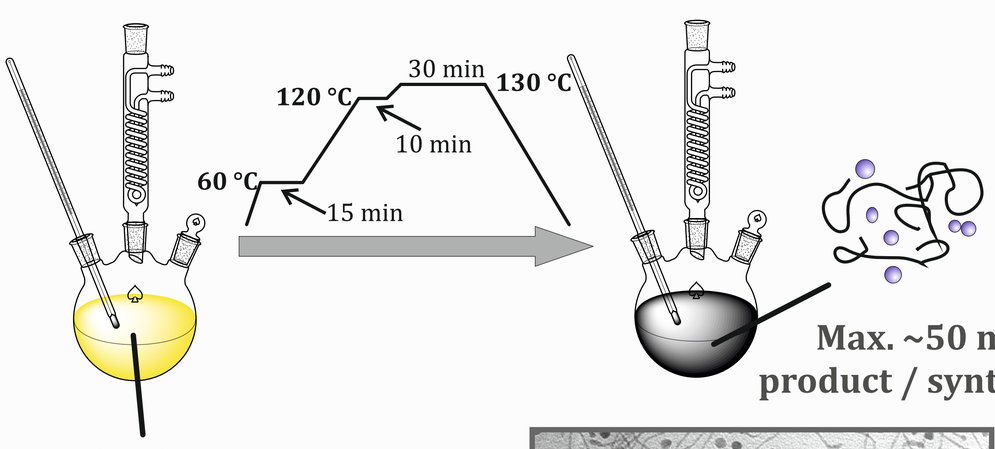
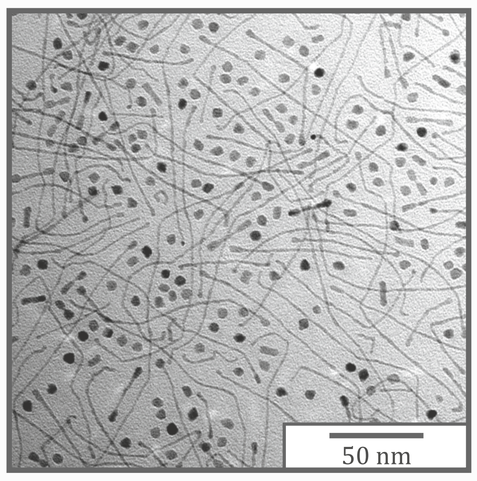
Aim

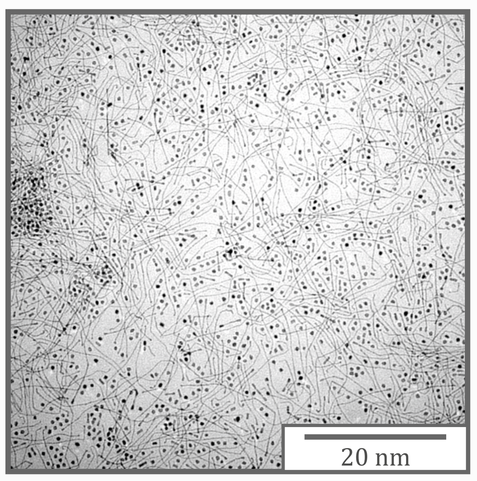
- Designing the synthetic protocols for cost effective, monodisperse, uniform in size, shape and highly crystalline metal/metal oxide nanoparticles with focus on anisotropic morphologies.
- Implementation and optimization of these protocols in batch wise synthesis techniques such as microfluidic reactors (microreactors) to obtain the scaled up amounts of nanomaterials.
- Exploring the novel applications of these nanomaterials especially in catalysis.

Synthesis

Experimental Setup



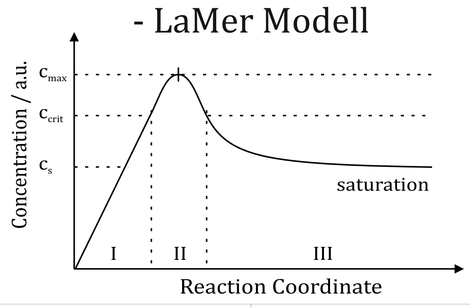




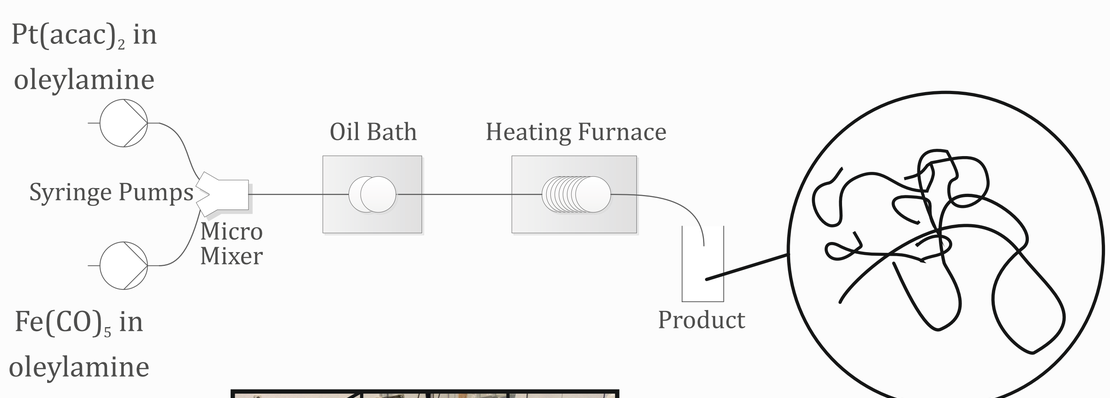
Upper: scheme of the flask syntheses.
Lower: TEM pictures of the as produced Pt nanowires.

Sun et. al. *J. Am. Chem. Soc.* **2007**, 129, 6974-6975.
Lu et. al. *Nano Res.* **2012**, 5(3), 145-151.

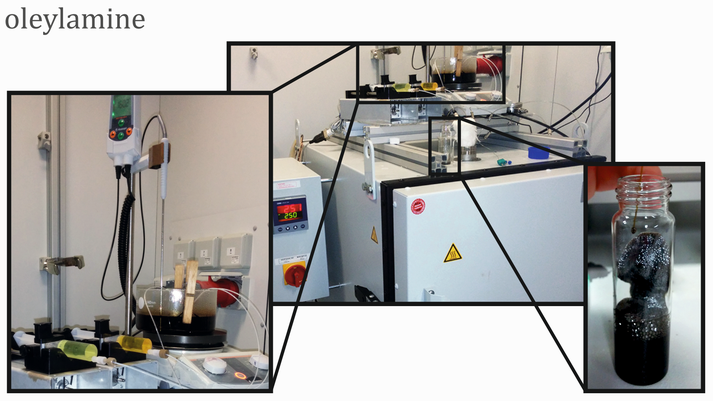
Nucleation and Crystal Growth - LaMer Modell



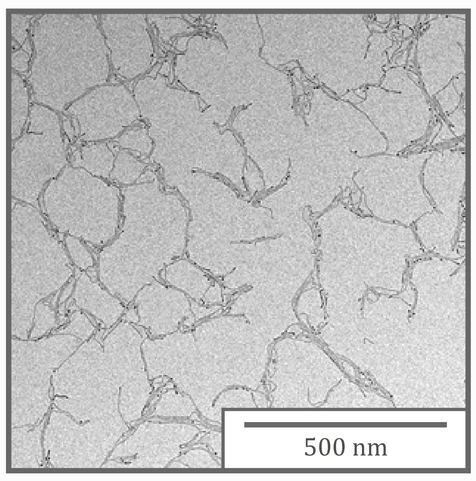
Microfluidic Setup

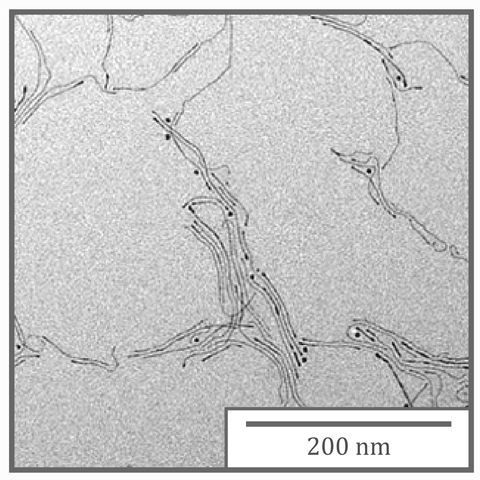


~200 mg Product / hour

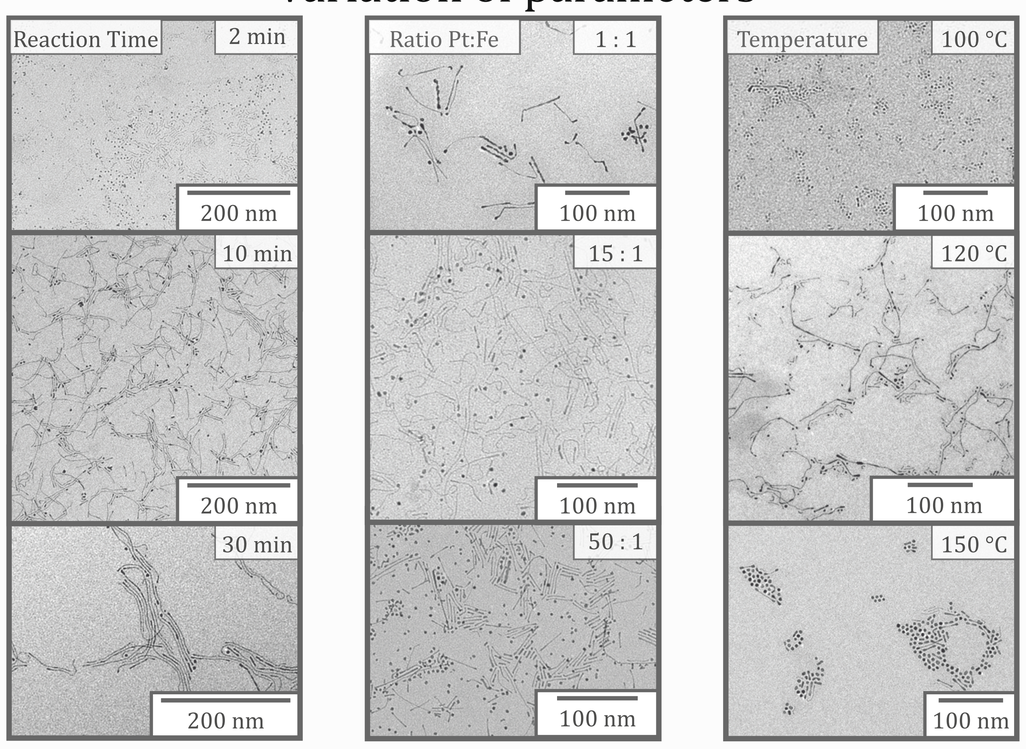


Upper picture: scheme and pictures of the microfluidic setup.
Lower picture: TEM pictures of the as produced Pt nanowires.



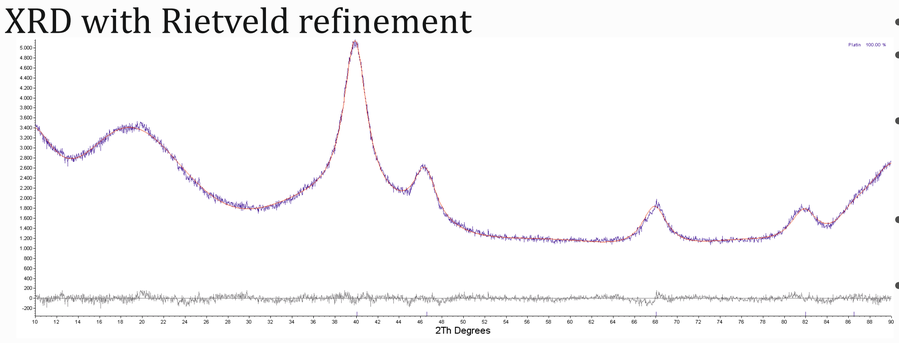


Variation of parameters



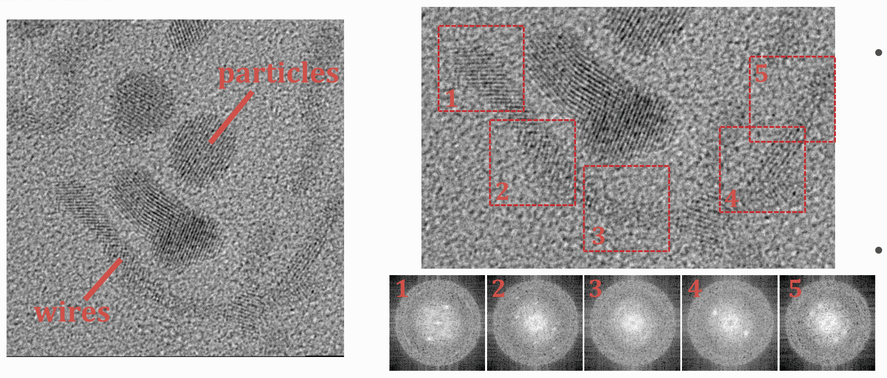
Analytics

XRD with Rietveld refinement



- No traces of iron detectable.
- Refinement confirms the alignment in the (111) direction.
- Lattice constant is 3,895 Å, differs slightly from 3,998 Å in bulk.
- Coherent scattering areas are calculated to 3,639 nm.
- Fits to thickness of nanowires as determined in TEM analysis (~ 3 nm).

HR-TEM



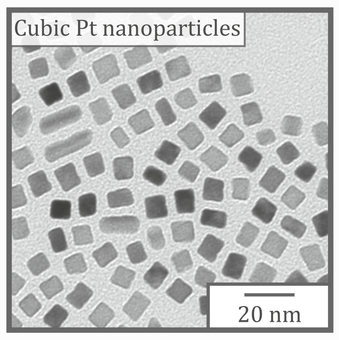
- left side:
  Wires are Pt; round, isolated particles have different periodicity (Fe?).
  Twinned particles are also Pt and could be wire precursor.
- right side:
  Pt wires are not a continuous lattice, but have grains (all with same lattice).

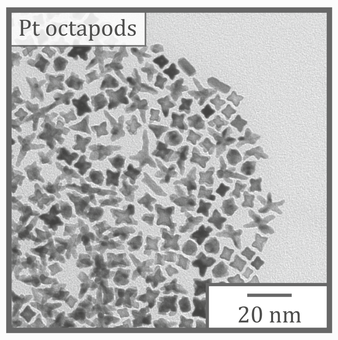
W. Tremel et al., *manuscript pending.*

Conclusion

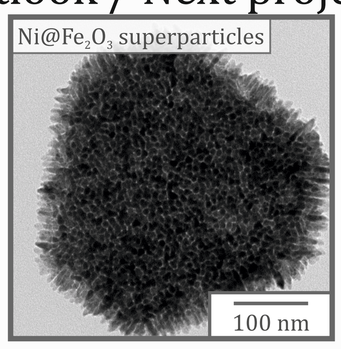
- Synthesis and characterization of monodisperse platinum nanowires.
- Development of continuous batch process to get gram amounts of these nanomaterials (~200 mg / hr).
- A genereal approach for microfluidic syntheses of complex nanoparticles with reproducible shapes and compositions.

Outlook / Next projects

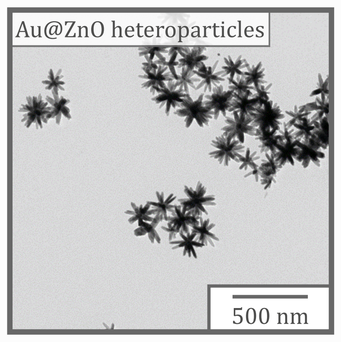




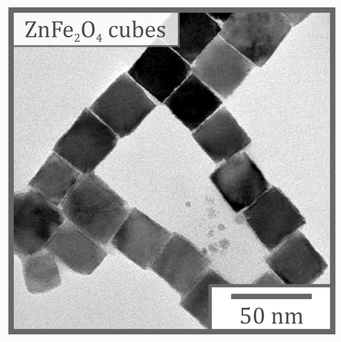
W. Tremel et al., *manuscript pending.*



W. Tremel et al., *ACS Nano*, 2016, Advance Article.



W. Tremel et al., *Nanoscale*, 2013, **5**, 9944-9949.



W. Tremel et al., *Nanoscale*, in preparation.