Nano(diagno)stix

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These: One future of diagnostics might be nanoparticles !

Different targets

- o MRI contrasting agents (crystalline Oxides, Fe, PtCo)
- o Positron emmission spectroscopy, PET (CaF_2)
- o NIR- optical pictures (special dye nanoparticles)
- o ex vivo: Q-dots for cell marking, multi-colour assays)
- o X-ray contrasting agents (electorn rich materials, e.g. RJ, $BaSO_4$)
- o microwave diagnostics
- o ultrasound contrasting agents (rather in the micron range)
- o hyperthermia (treatment)

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But particles have to be non-toxic, stealthy, or even tissue specific

o dose either intravenous or oral

o oral: „stealth properties“ required; depends on size and surface chemistry

o „active“ and „passive“ targeting

o decomposition schemes or excretion must be foreseeable

o no synthetic side products, no Pt, Cd, Pb, Hg……

Classic: Q-dot multicolour assay

- High quantum yield
- High absorption coefficient
-- High stability

Classic: gold clusters

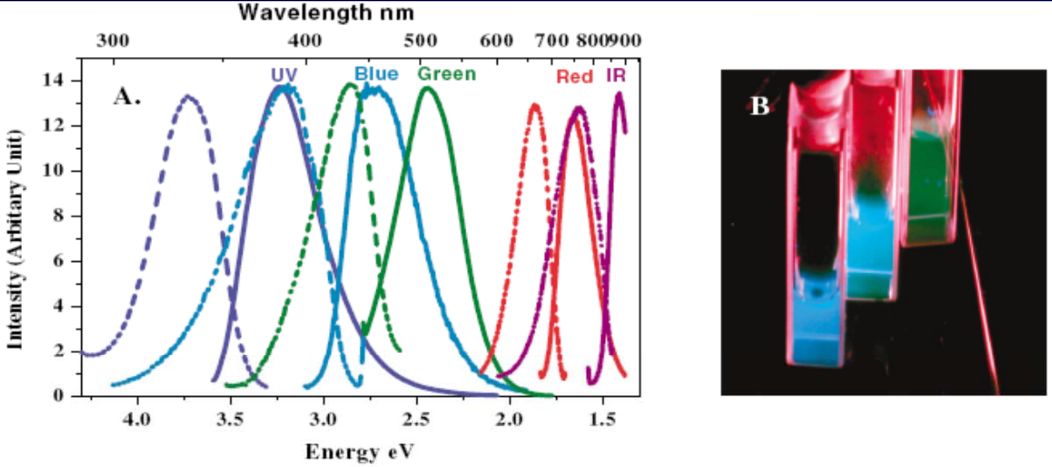
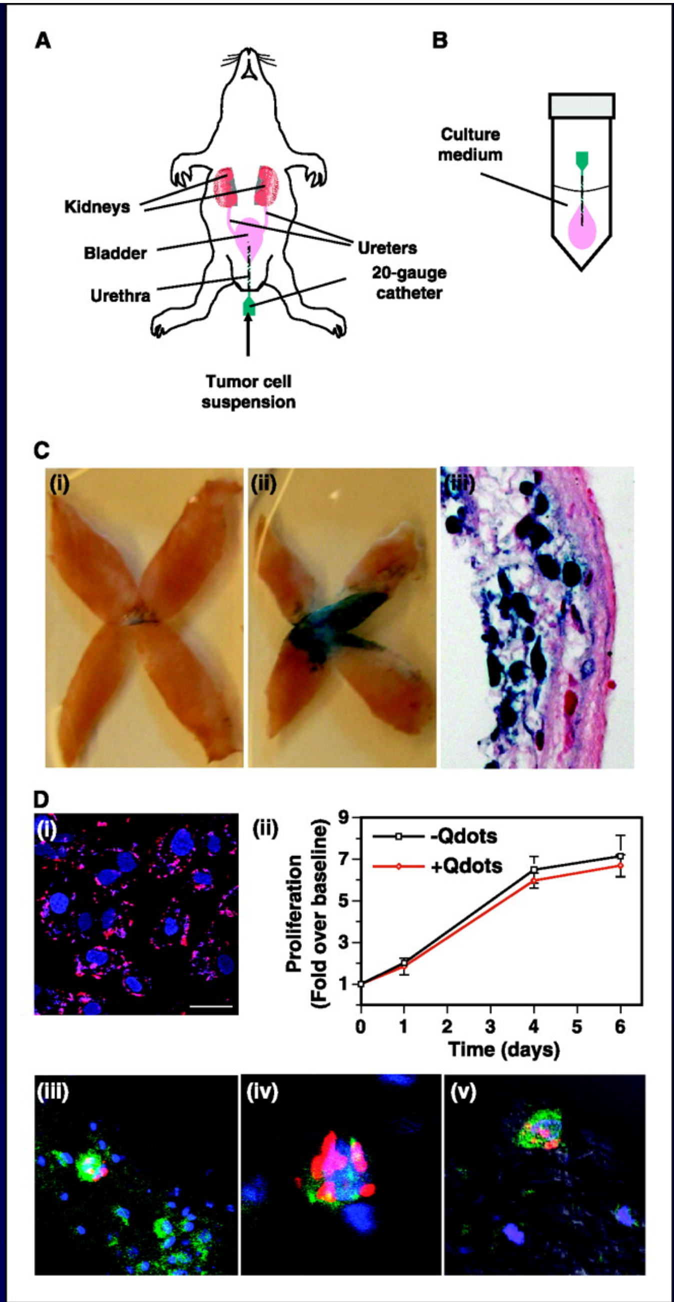


FIG. 1 (color). (a) Excitation (dashed) and emission (solid) spectra of different gold nanoclusters. Emission from the longest wavelength sample was limited by the detector response. Excitation and emission maxima shift to longer wavelength with increasing initial Au concentration [16], suggesting that increasing nanocluster size leads to lower energy emission. (b) Emission from the three shortest wavelength emitting gold nanocluster solutions (from left to right) under long-wavelength UV lamp irradiation (366 nm). The leftmost solution appears slightly bluer, but similar in color to Au_8 (center) [14] due to the color sensitivity of the human eye. Green emission appears weaker due to inefficient excitation at 366 nm.



Estrada, C. R. et al. Cancer Res 2006;66:3078-3086

4 synthesis technologies

o Non-aqueous sol-gel synthesis (crystalline Oxides)

o Polymer controlled precipitation (Ionic and molecular crystals)

o Polymer Chimera Technology (Micelles and targeting)

o Miniemulsification/ Encapsulation (amorphous nanoparticles)

Part 1:

The “Niederberger” pathway to some new oxidic nanoparticles

What to choose:Metal Oxides Nanomaterials

Metal oxides are a class of materials with properties covering almost all aspects of materials science and solid state physics (semiconductivity,luminescence, ferroelectricity, magnetism, X-ray optics, optical properties...)

Furthermore: Tailoring possible by doping!

Usually non toxic, very stable !!!

(opposite to standard q-dots as CdS, PbTe.....)

Some particularly promising applications for diagnostics

Part A: A Novel Synthesis of MeO Nanoparticles

General Synthesis Protocol:

All procedures were carried out in the glovebox.

1) Dissolve Alkali Metal (Li) or Alkaline Earth Metals (Sr,Ba) in Benzyl Alcohol ($C_6H_5CH_2OH$)
2) Addition of Metal Alkoxides: $Ti(O^iPr)_4$, $Zr(O^iPr)_4$ or $Nb(OEt)_5$ $VO(O^iPr)_3$, $Nb(OEt)_5$, $Hf(OEt)_4$, $Ta(OEt)_5$, $Sn(O^tBu)_4$, $In(O^iPr)_3$
3) Heat treatment in autoclave at 200°C-250°C

(Boiling point of benzyl alcohol is 205°C)

No water, no halide precursors, no surfactants!

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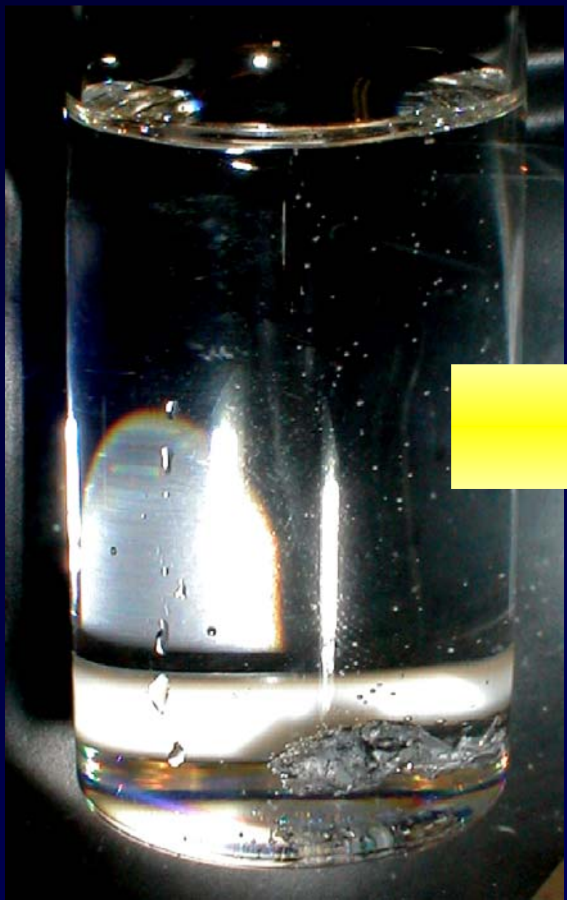
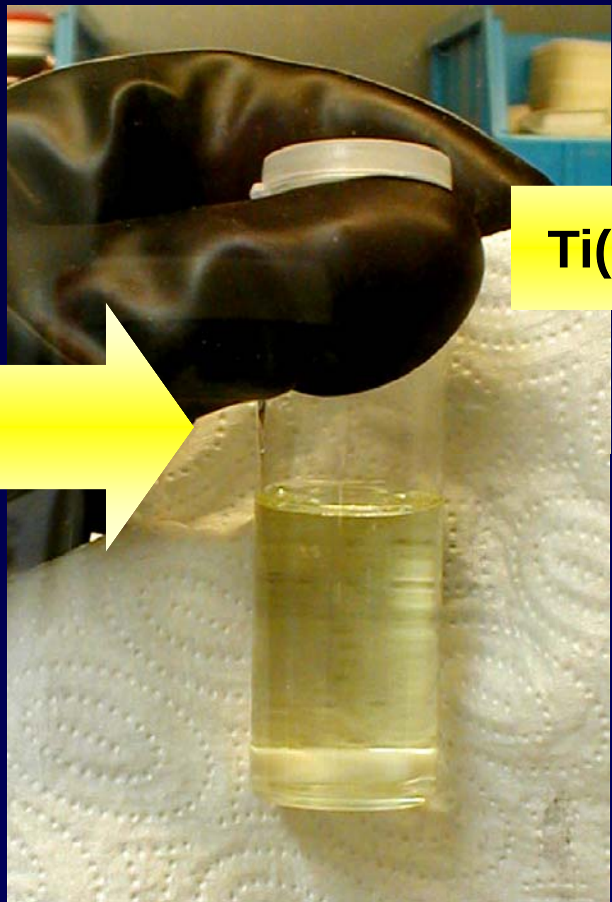
Typical Procedure: Synthesis of $BaTiO_3$





$Ti(O\textit{i}Pr)_4$

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Which materials are new as nanoparticles ?

$$\text{Ba} + \text{Benzyl Alcohol} + \text{Ti(O}i\text{Pr)}_4 \xrightarrow{200°\text{C}} \text{BaTiO}_3$$

$$\text{Sr} + \text{Benzyl Alcohol} + \text{Ti(O}i\text{Pr)}_4 \xrightarrow{200°\text{C}} \text{SrTiO}_3$$

$$\text{Ba,Sr} + \text{Benzyl Alcohol} + \text{Ti(O}i\text{Pr)}_4 \xrightarrow{200°\text{C}} \text{(Ba,Sr)TiO}_3$$

$$\text{Li} + \text{Benzyl Alcohol} + \text{Nb(OEt)}_5 \xrightarrow{220°\text{C}} \text{LiNbO}_3$$

Angew. Chem. Int. Ed. **2004**, *43*, 2270-2273 – JACS 2004, 126, 9120 – German Patent Nr. 103 38 465.0

Angew. Chem. Int. Ed. 2004, 43, 4345, Adv. Mater. 2004 in Print, Coll. Surf. A 2004 in Print, German Patent Nr. 10 2004 016 131.3

Characterization: TEM

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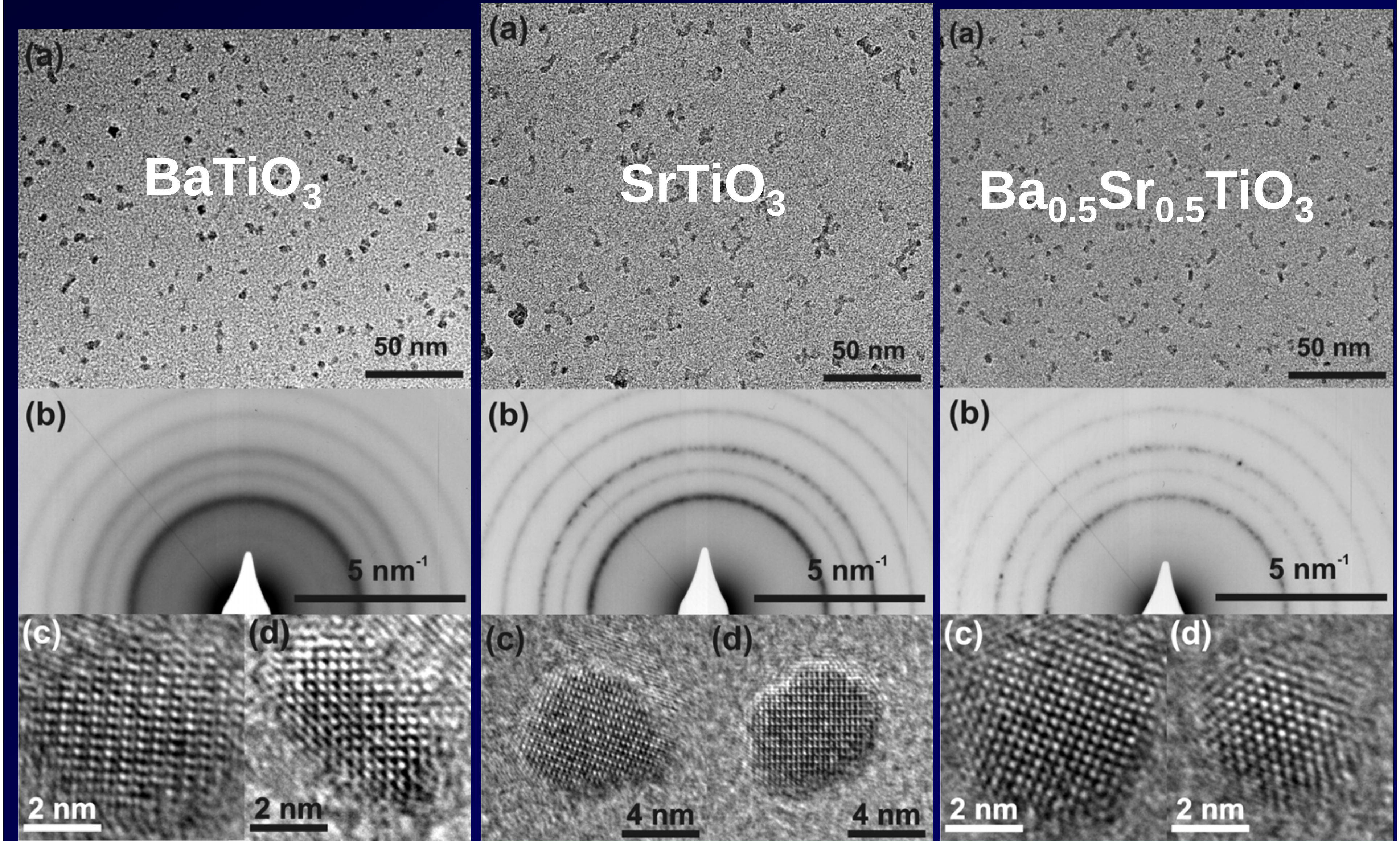
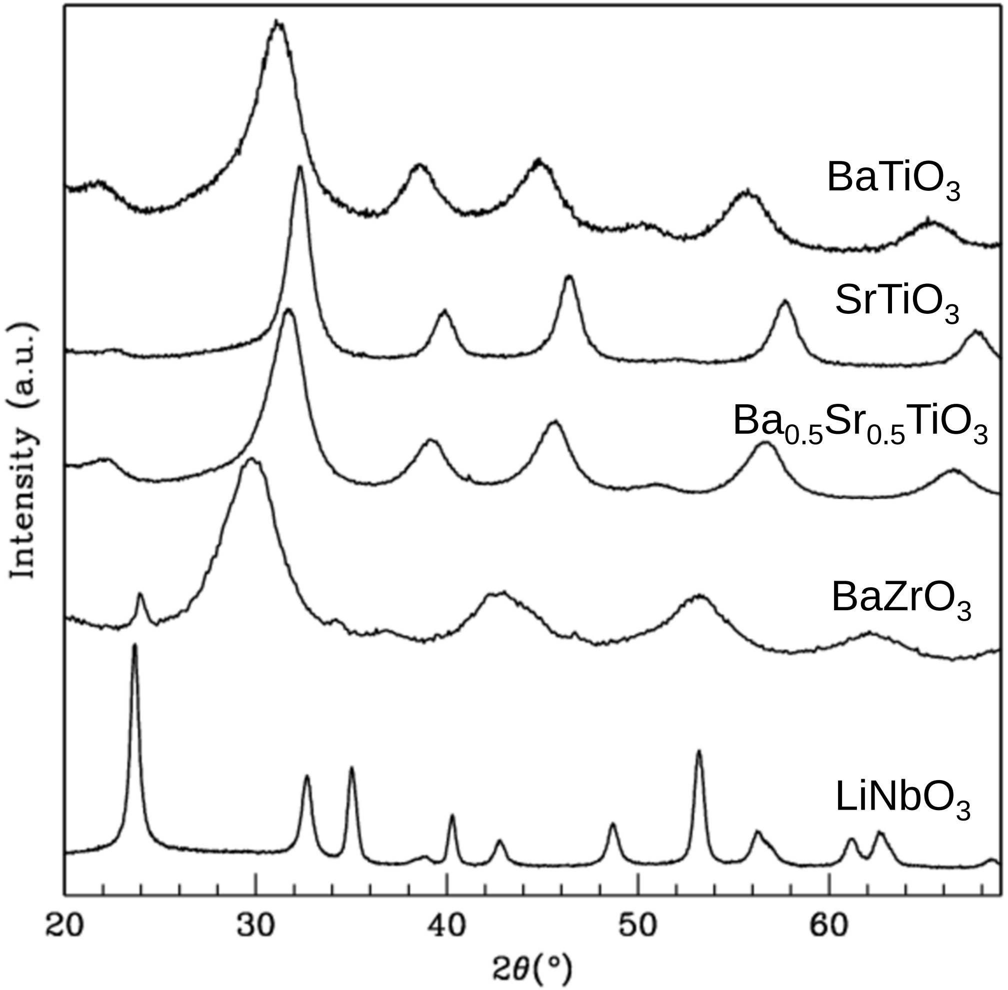


Characterization: X-ray Powder Diffraction



Titanates:

- Phase-pure
- Broad peaks
- Discrimination cubic-tetragonal impossible

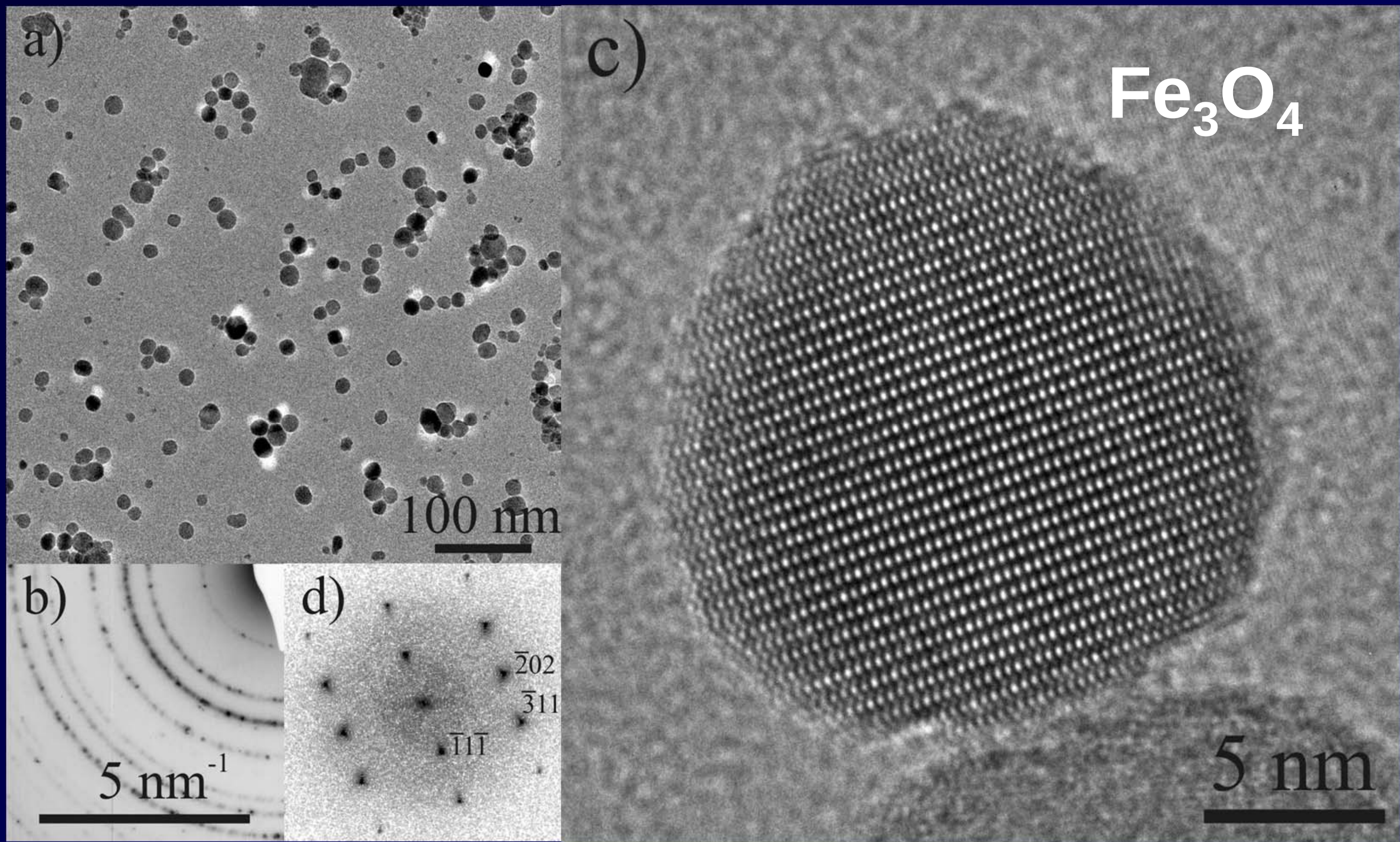
Bariumzirconate:

- $BaZrO_3$ + $BaCO_3$

Lithiumniobate:

- Sharper reflections
- Phase-pure

TEM – Characterization of magnetic Nanoparticles



Characterization: Electron Microscopy

HfO_2