New approaches in obtaining nano- and microstructured sol-gel materials with improved properties and functionality

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Motivation

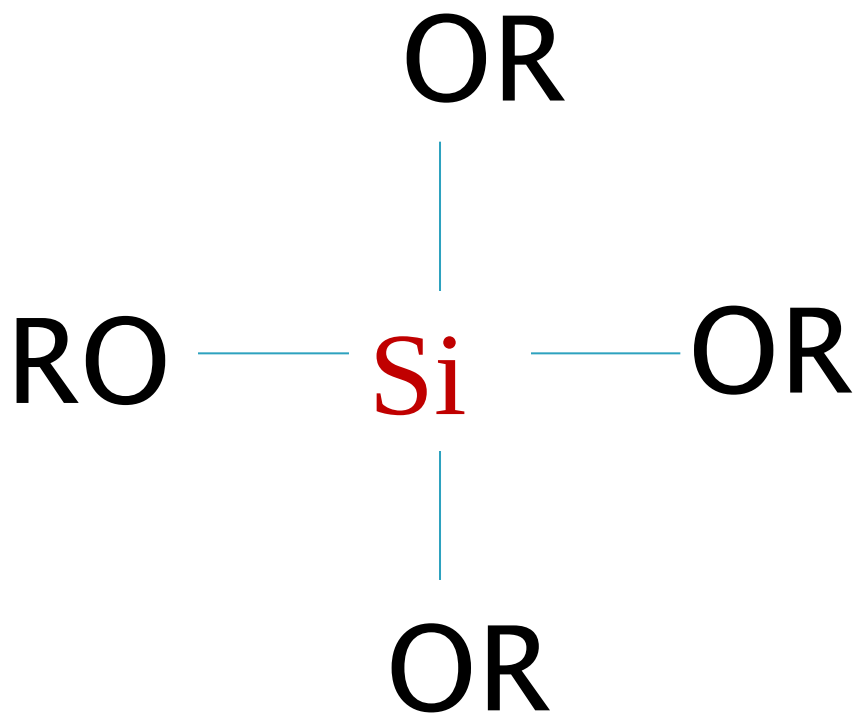
Sol-gel synthesis of metal oxide materials for applications:

- Fibers;
- CNT doped fibers;
- Microtubular structures;
- GDLC (gel-glass dispersed liquid crystals) films.

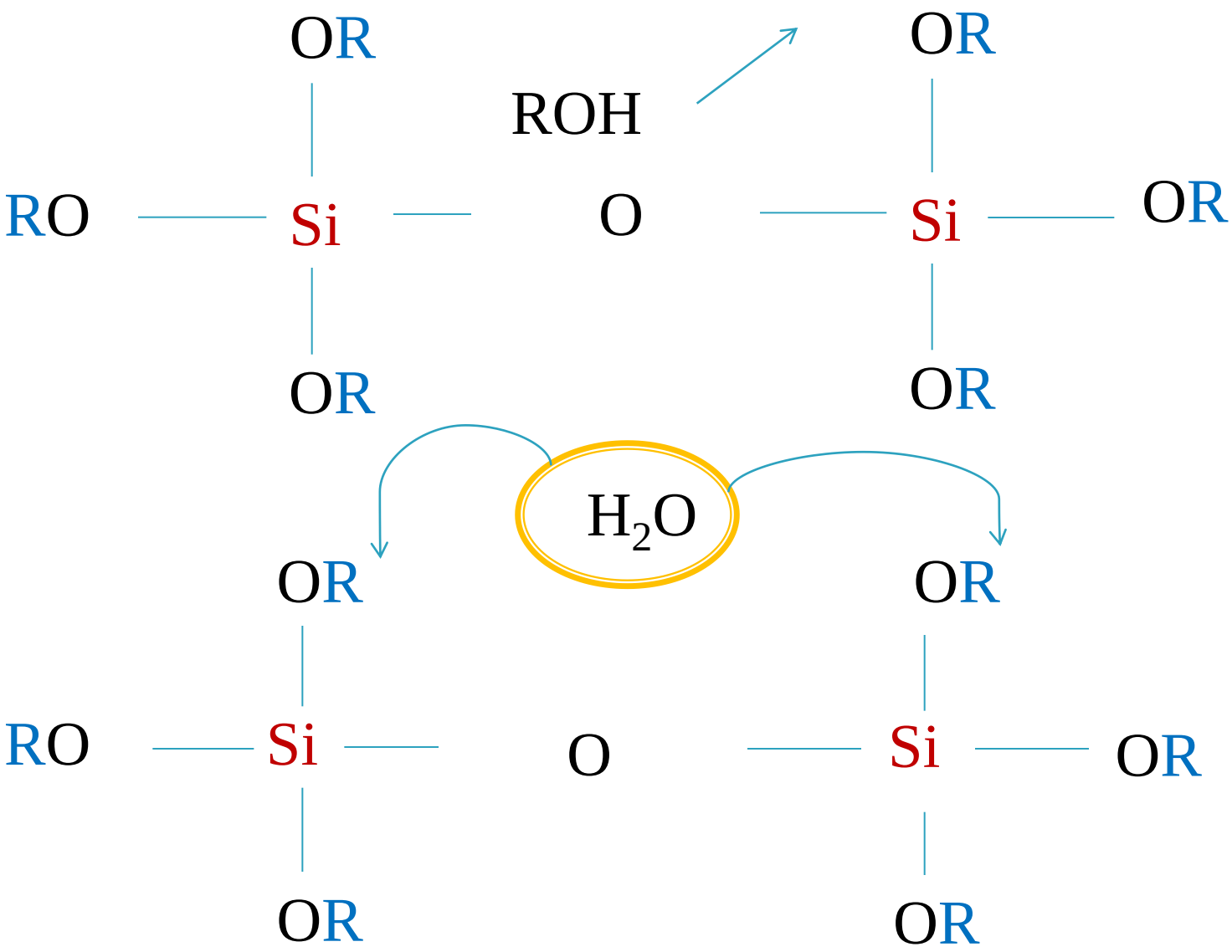
What is what…

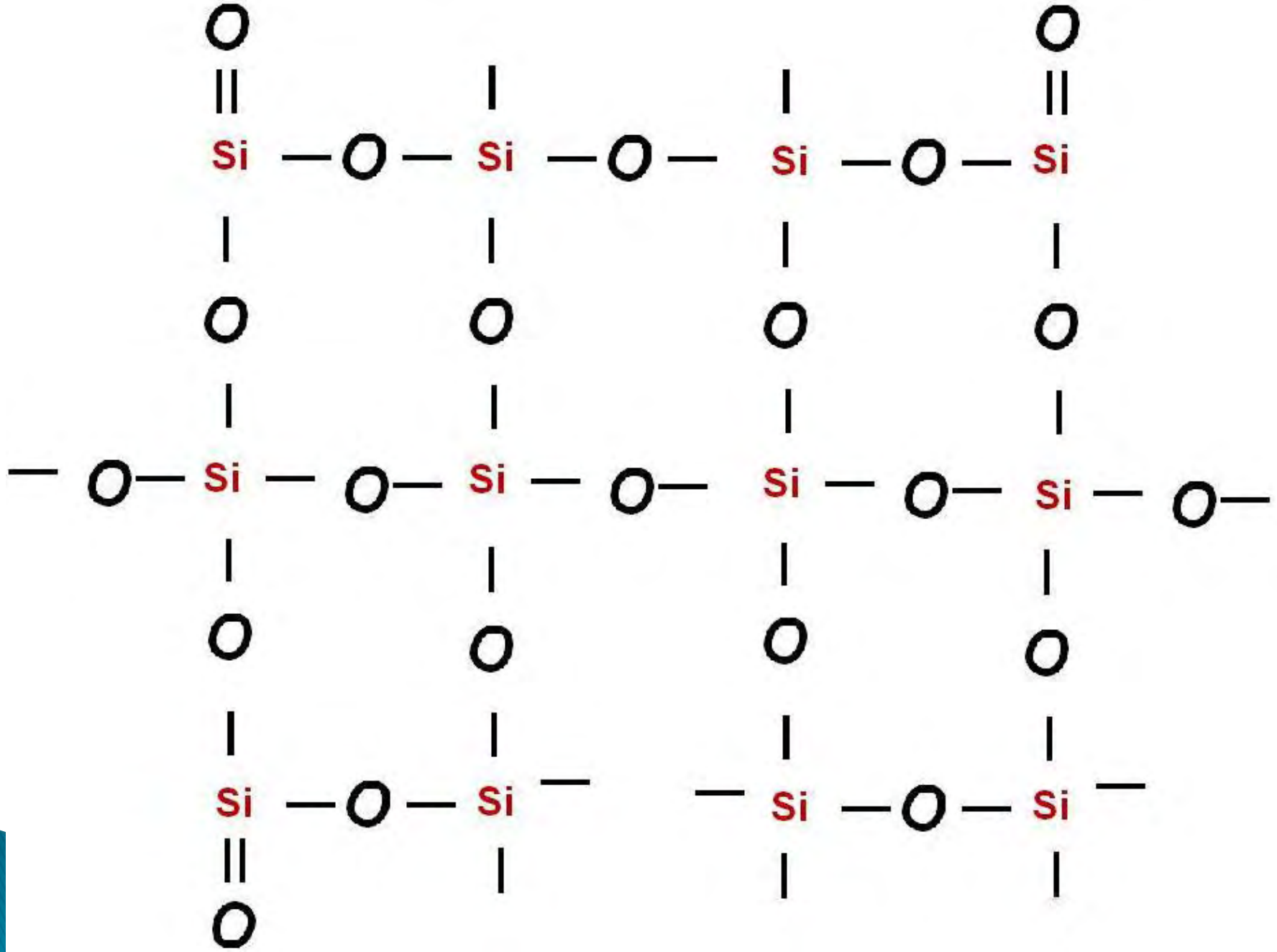
- **Sol** is a nanocolloidal suspension in a continuous liquid/gas medium.
- **Gel** is a nanocolloidal suspension where the particles are cross-linked into elastic network.
- **Sol-Gel transition** is a sols gelation process.

Sol-gel technology

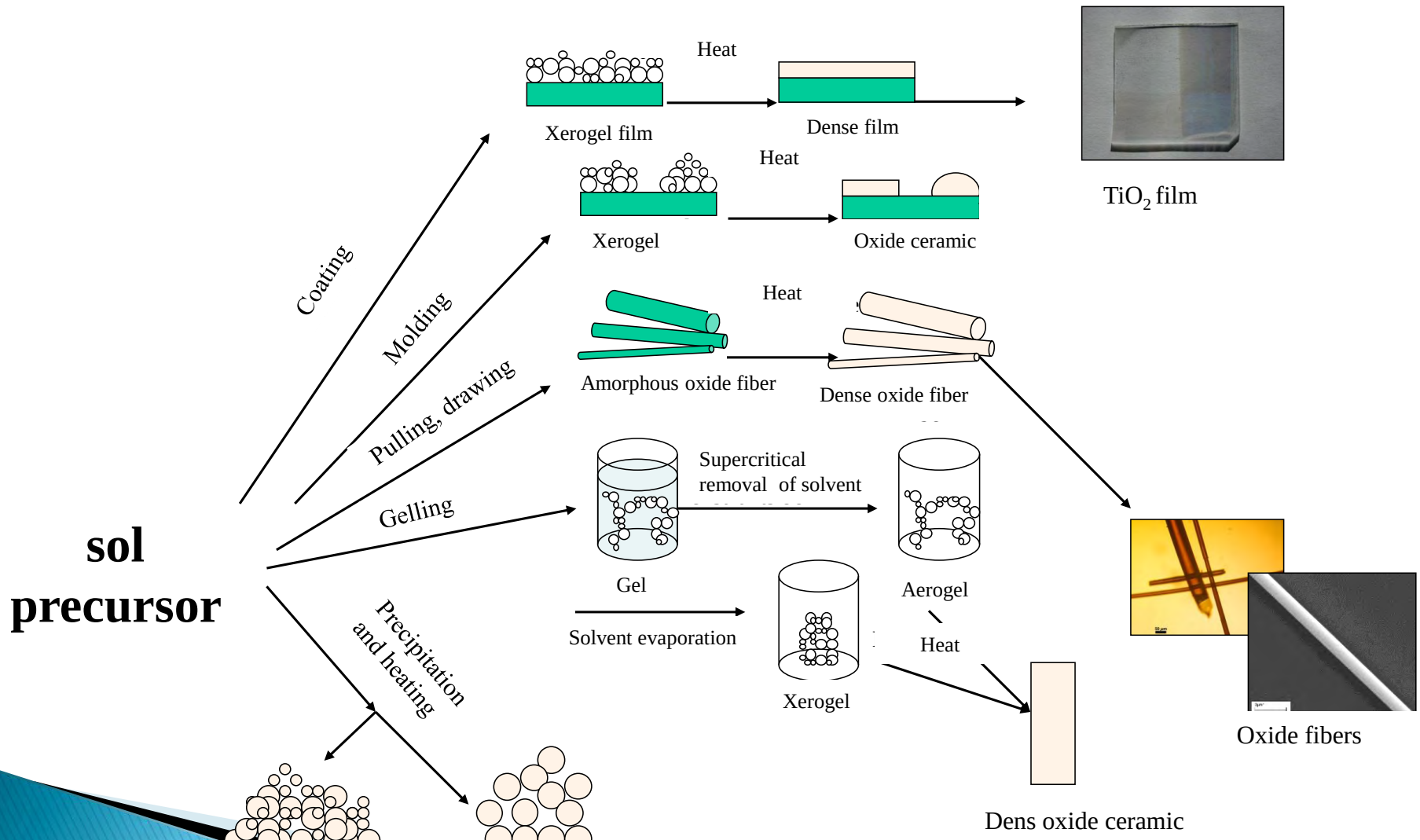


-OR is alkoxy group like
-OMe, -OEt, -OPr, -OBu


OR
ROH
OR
RO
Si
O
Si
OR
OR
OR
H2O
OR
OR
RO
Si
O
Si
OR
OR
OR



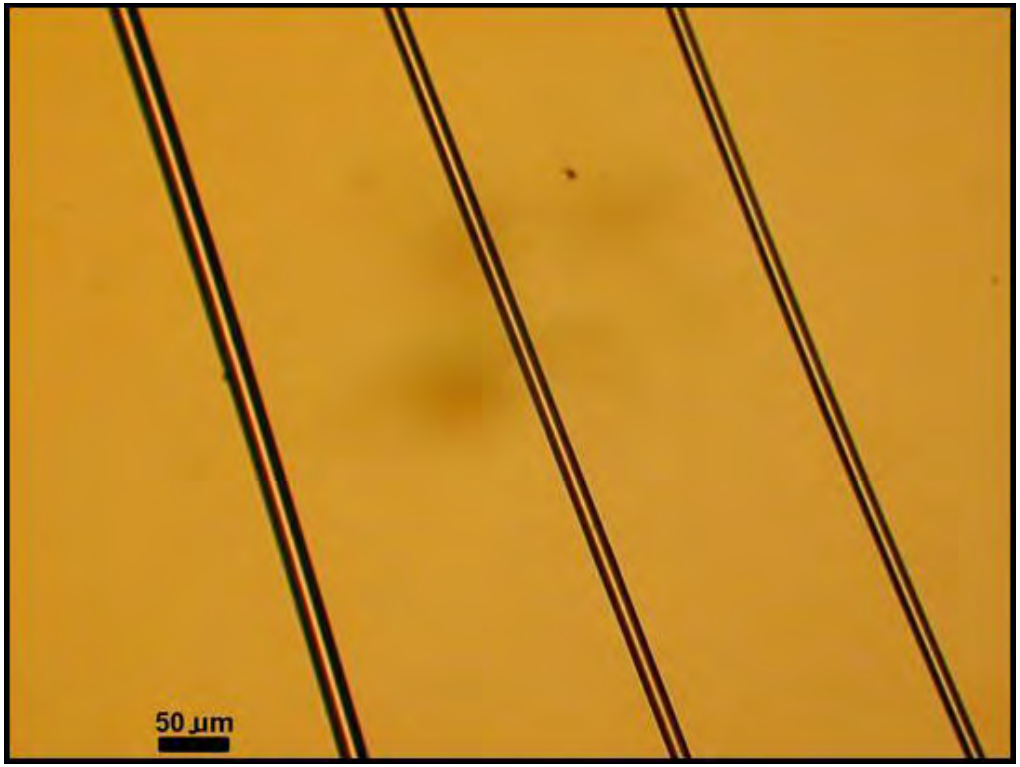
Introduction: Sol–gel technology products



TiO_2 film

V. Reedo , Elaboration of IVB group metal oxide structures and their possible applications, *Ph.D thesis,* University of Tartu, 2008. (available on-line)

Metal oxide fibers

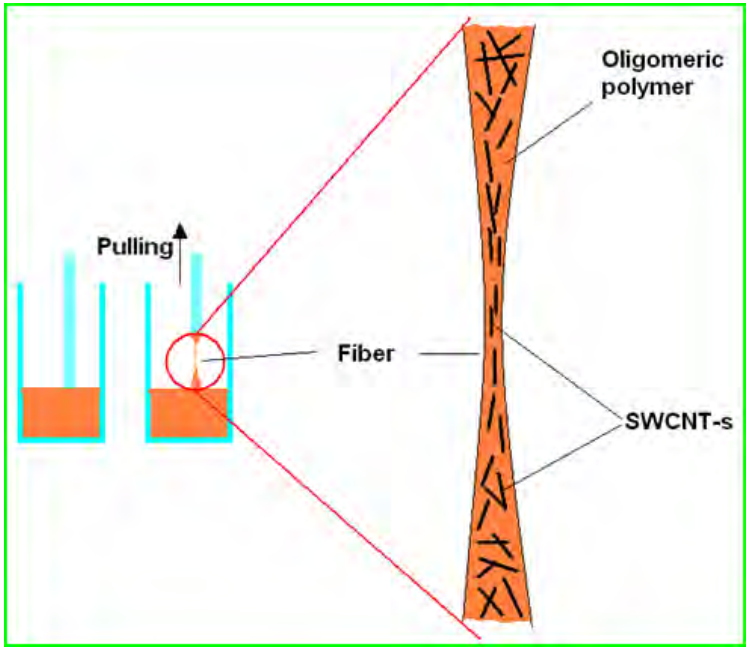


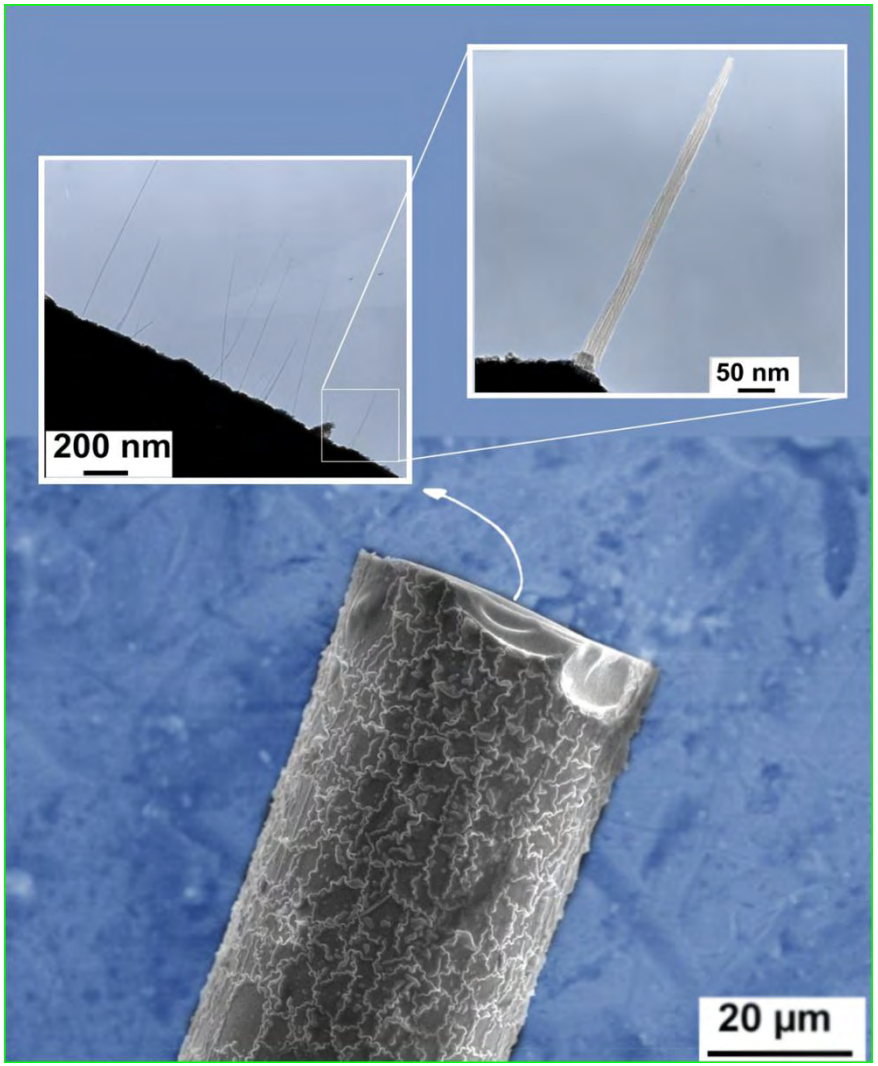
- Ti, Zr, Hf, Sn oxide fibers;
- directly drawn from precursor;
- several centimeters long;
- diameters ranging from ~200 nm up to ~100 µm;

Potential applications: waveguides, novel applications (for example sensors) have been shown to be possible, when the diameter is reduced to some micron scale.

Tätte, T.,Hussainov, M., Paalo, M., Gurauskis, J., Mändar, H., Lõhmus, A., Structure and Rheological Behavior of Alkoxide-Based Precursors for Drawing of Metal Oxide Micro- and Nanofibres. Advanced Materials Research, 214 (2011), 354 - 358.

CNT doped metal oxide fibers





- Maximum conductivity 500 S/m on fibers doped by 0,1 wt % SWCNT.

Microscopic tubular oxide structures

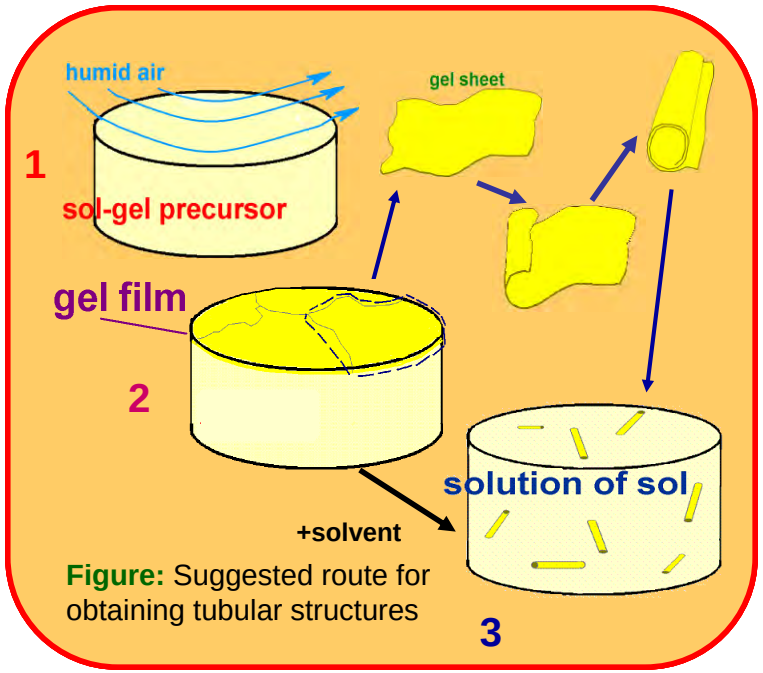
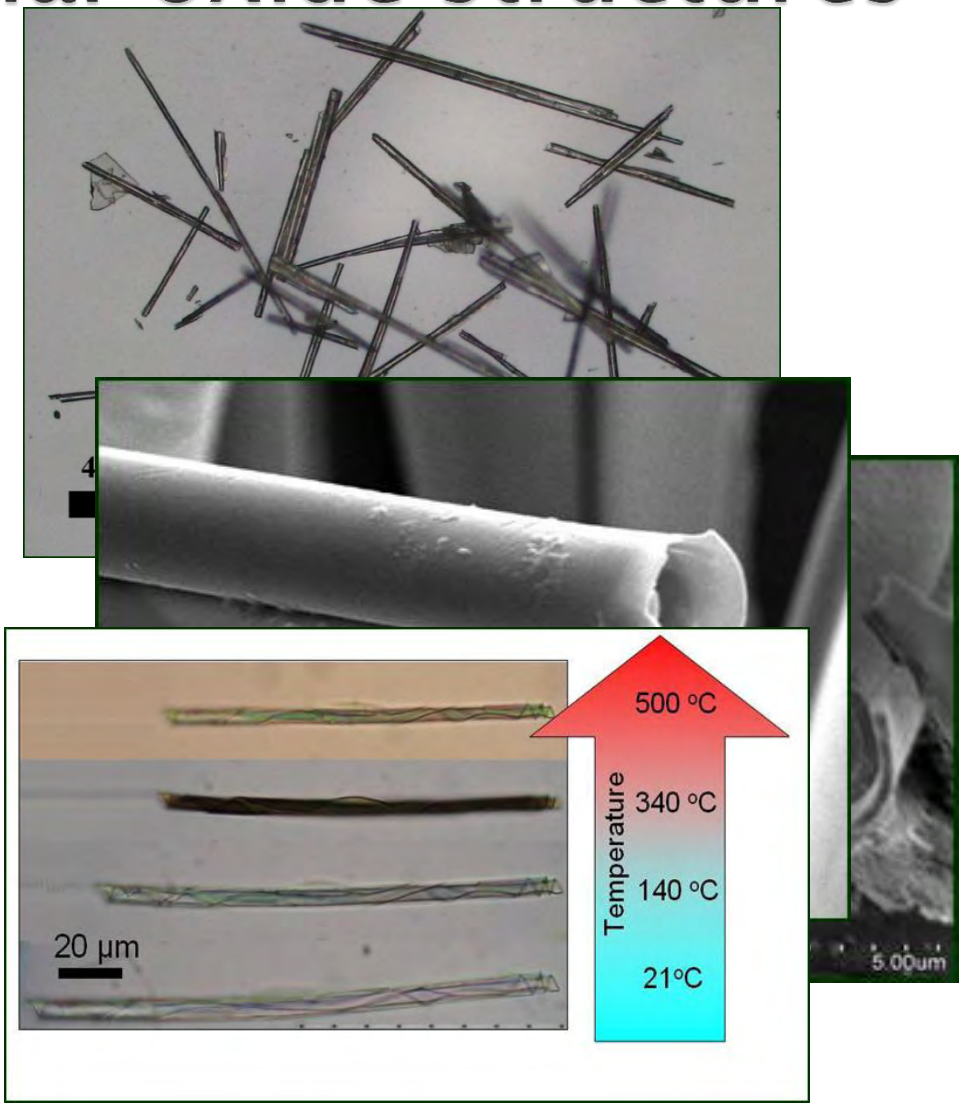


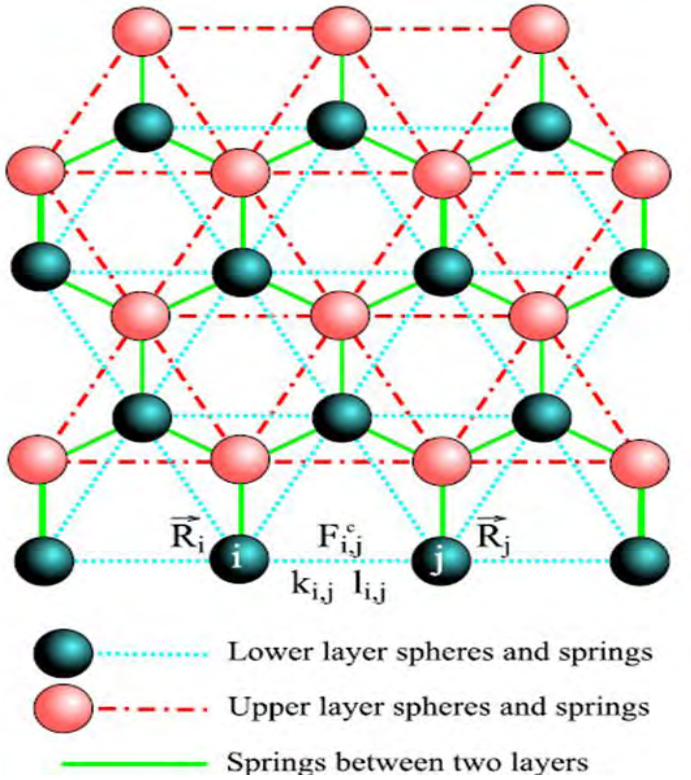
Figure: Suggested route for obtaining tubular structures

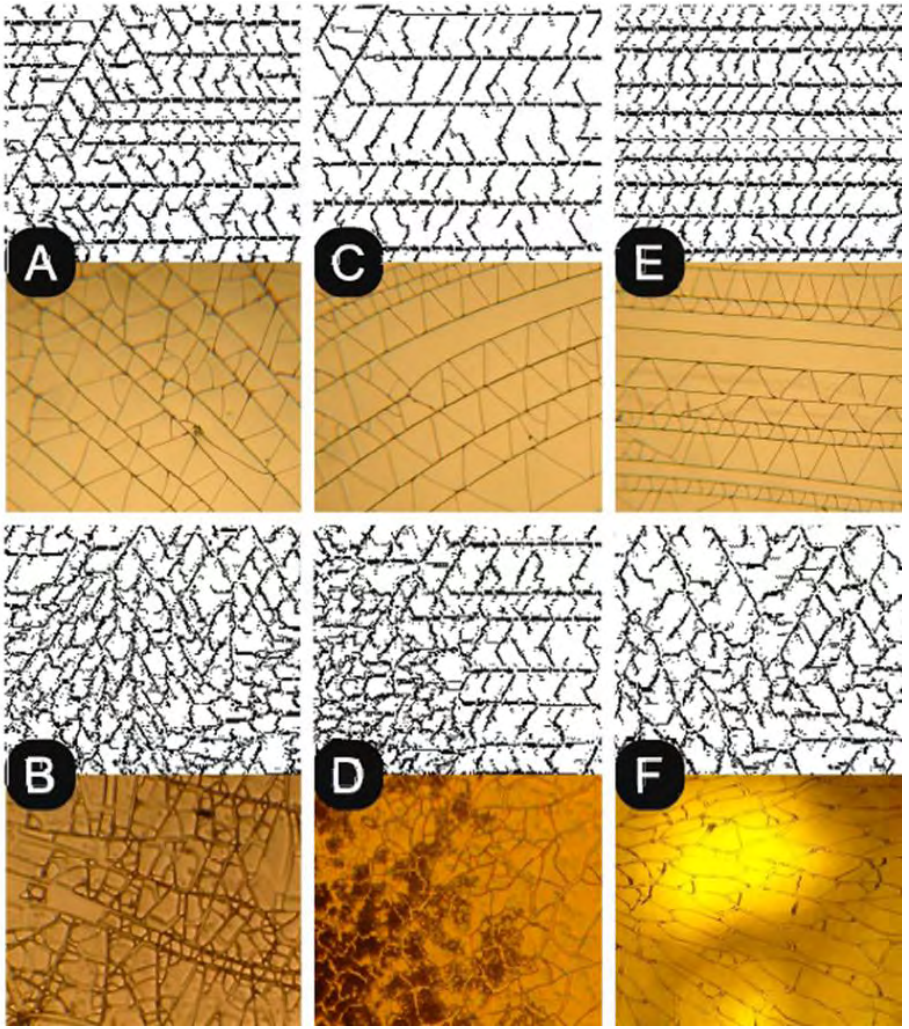


- 2–10 µm in diameter;
- 1 mm long;
- shrink 30 % (up to 500 ° C).

Järvekülg, M., Välbe, R., Salundi, A., Reedo, V., Part, M., Mäeorg, U., Lõhmus, A., A sol–gel approach to self–formation of microtubular structures from metal alkoxide gel films, *Apply. Phys. Letters (manuscript)*

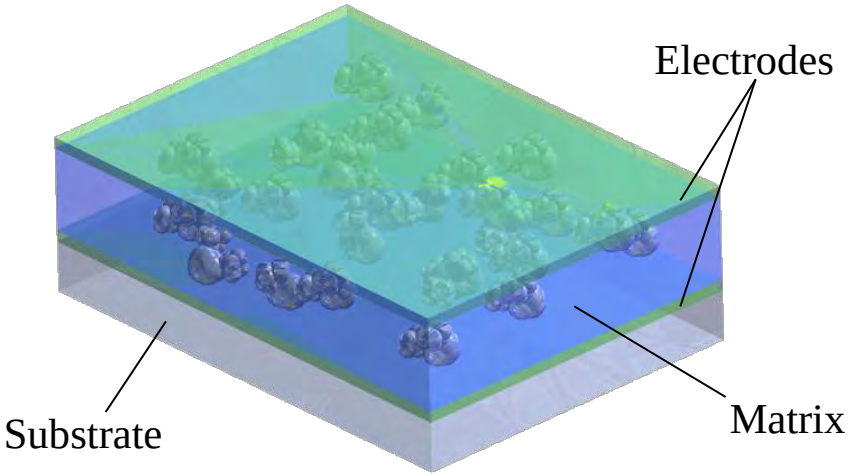
Simulation of cracking



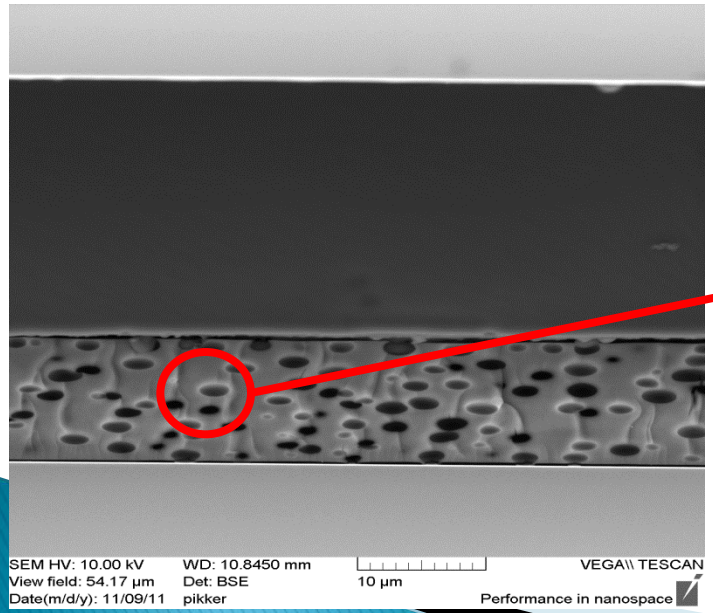


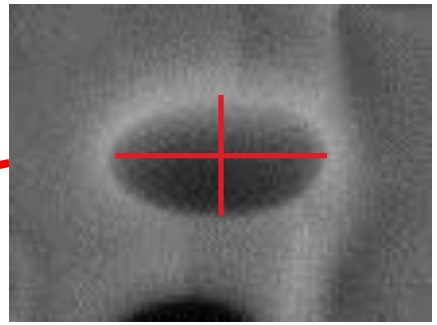
Jõgi, J., Järvekülg, M., Kalda, J., Salundi, A., Reedo, V., Lõhmus, A., Simulation of cracking of metal alkoxide gel film formed on viscous precursor layer using a spring-block model, EPL - A Letters Journal Exploring the Frontiers of Physics, 95(6) (2011), 64005-p1 - 64005-p6.

GDLCs (gel-glass dispersed liquid crystals)



- Crack free, large thickness
- Large change in transmittance
- Matrix with high refractive index (ideally the dispersion curve of the matrix matces the dispersion curve of LC)





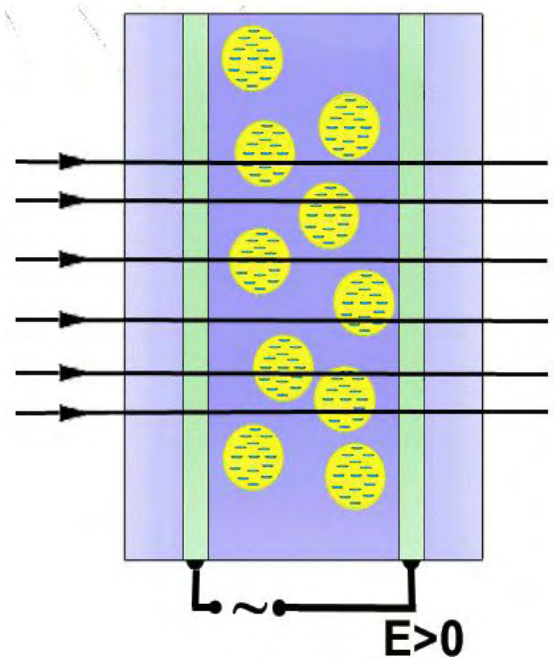
Drying → Sphere → Ellipsoid

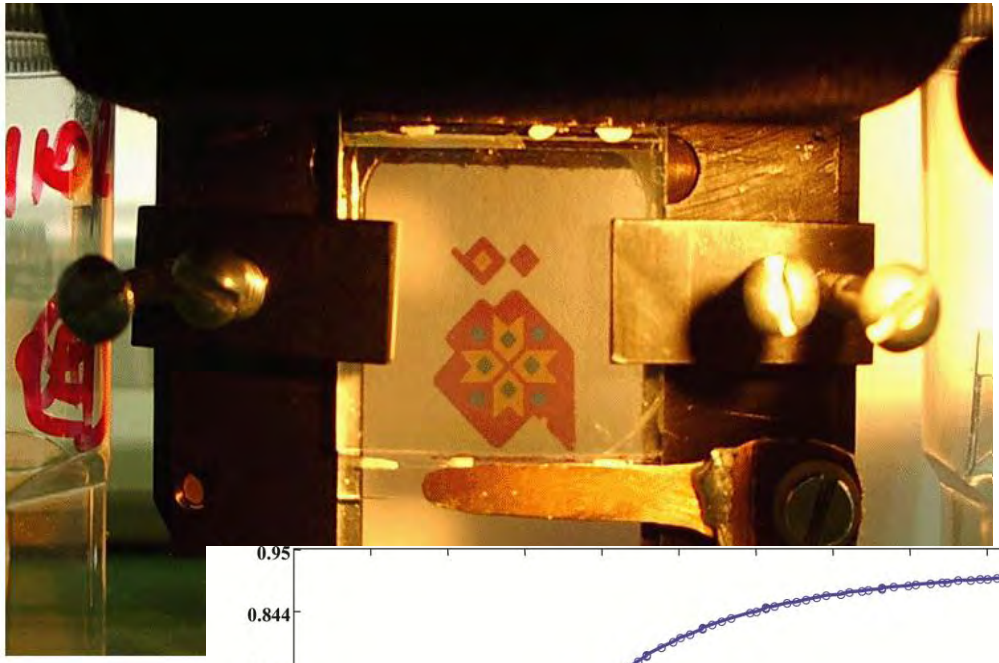
Average aspect ratio **0.476**
(ratio of the minor to major axis length)

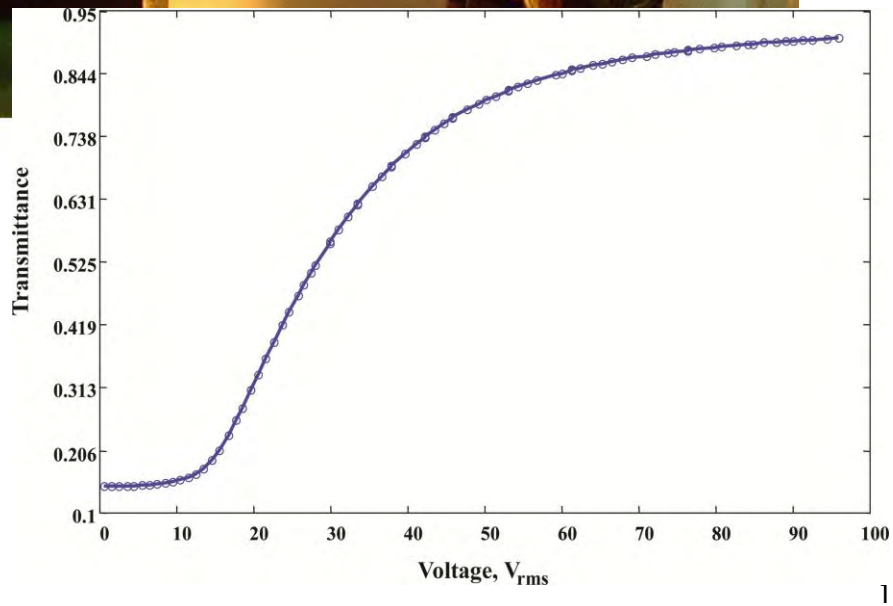
Timusk, M., Järvekülg, M., Lõhmus, R., Kink, I., Saal, K., Sol-gel matrix dispersed liquid crystal composite: Influence of methyltriethoxysilane precursor and solvent concentration, Materials Science and Engineering B, 172(1) (2010), 1 – 5.

GDLCs (gel-glass dispersed liquid crystals)

Principle of operation:



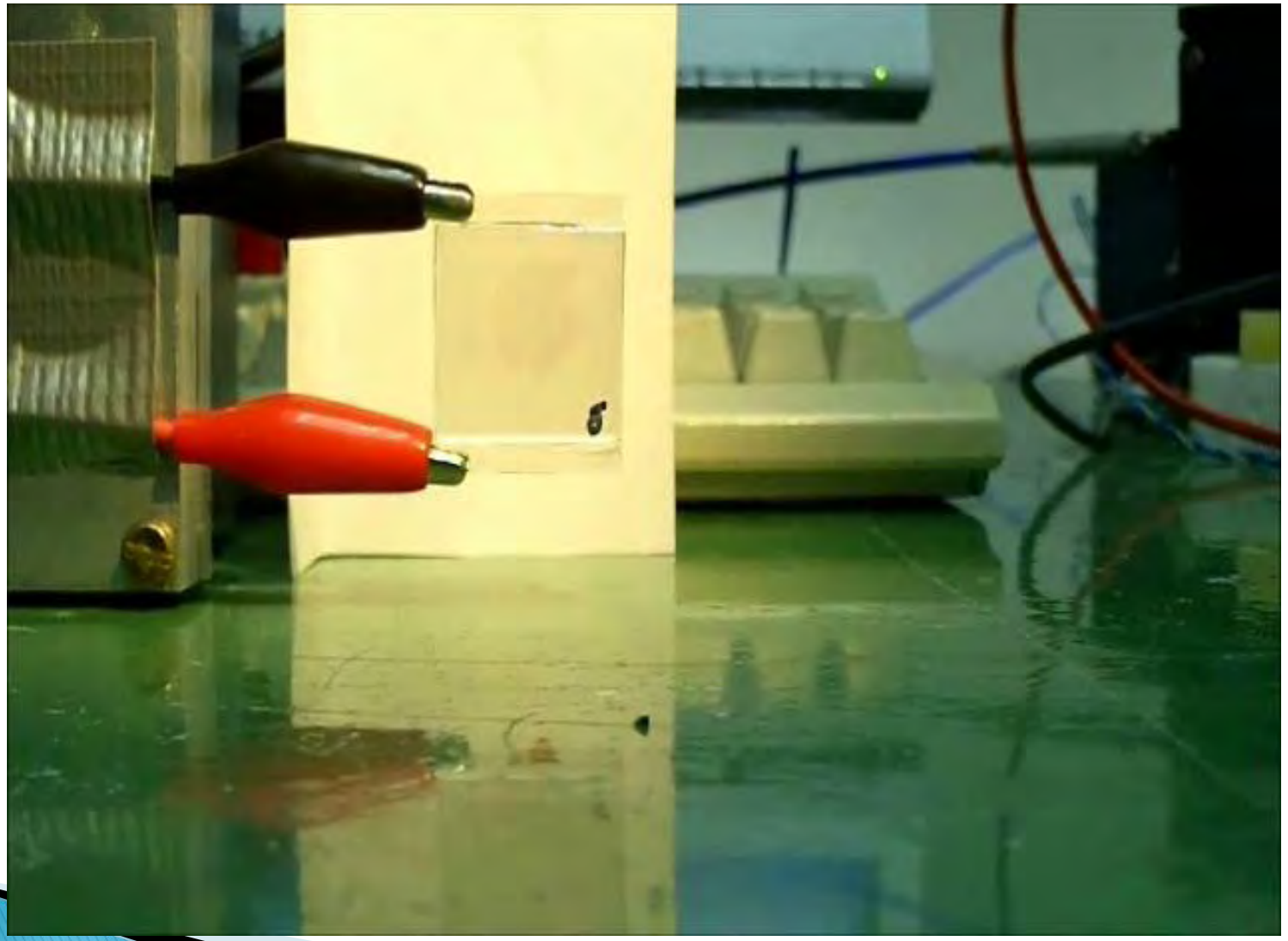




Transmittance:

$$T = \frac{I_t}{I_0}$$

Results



Conclusion

- Metal oxide fibers;
- CNT doped metal oxide fibers;
- Microscopic tubular oxide structures;
- GDLC films.

Acknowledgement

This work has been supported by SF0180058s07, ETF8420, ETF8377, ETF8428, Estonian Centre of Excellence "Mesosystems: Theory and Applications" (TK114), Estonian Nanotechnology Competence Center, TÜ and TTÜ Doctoral School "Functional Materials and Technologies".

Martin Timusk, Martin Järvekülg, Tanel Tätte, Marko Part, Valter Reedo, Jakob Jõgi, Madis Paalo, Kristjan Saal and Ants Lõhmus


"A cake slice" of GDLC film
Thank You for Your attention!
HV
10.00 kV
WD
4.0 mm
mag
7 999 x
det
ETD
10/21/2010
3:56:59 PM
curr
0.69 nA
5 µm
IP Univ Tartu