Sb_2S_3 ÕHUKESED ABSORBERKIHID POOL-LÄBIPAISTVATELE PÄIKESEPATAREIDELE

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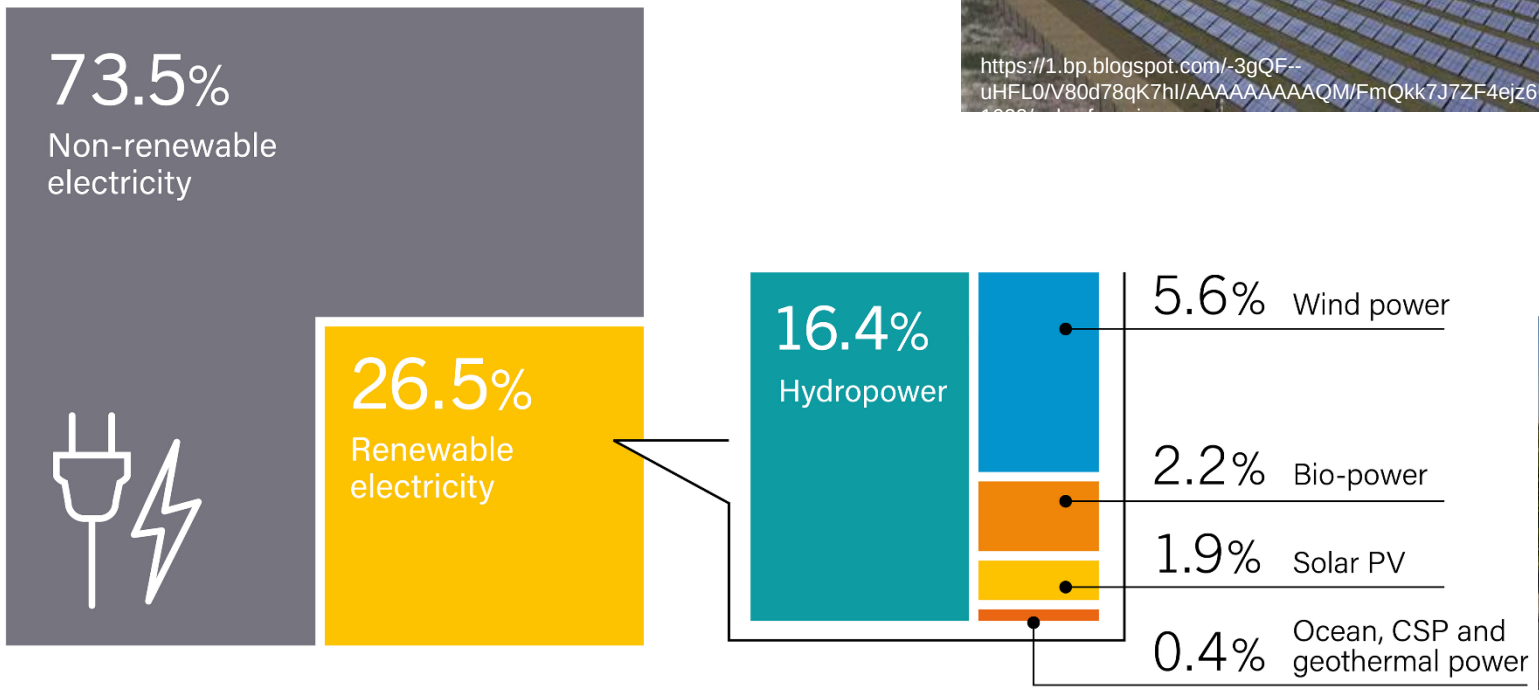
Materjali- ja keskkonnatehnoloogia instituut, Tallinna Tehnikaülikool

Photovoltaics

Estimated Renewable Energy Share of Global Electricity Production, End-2017

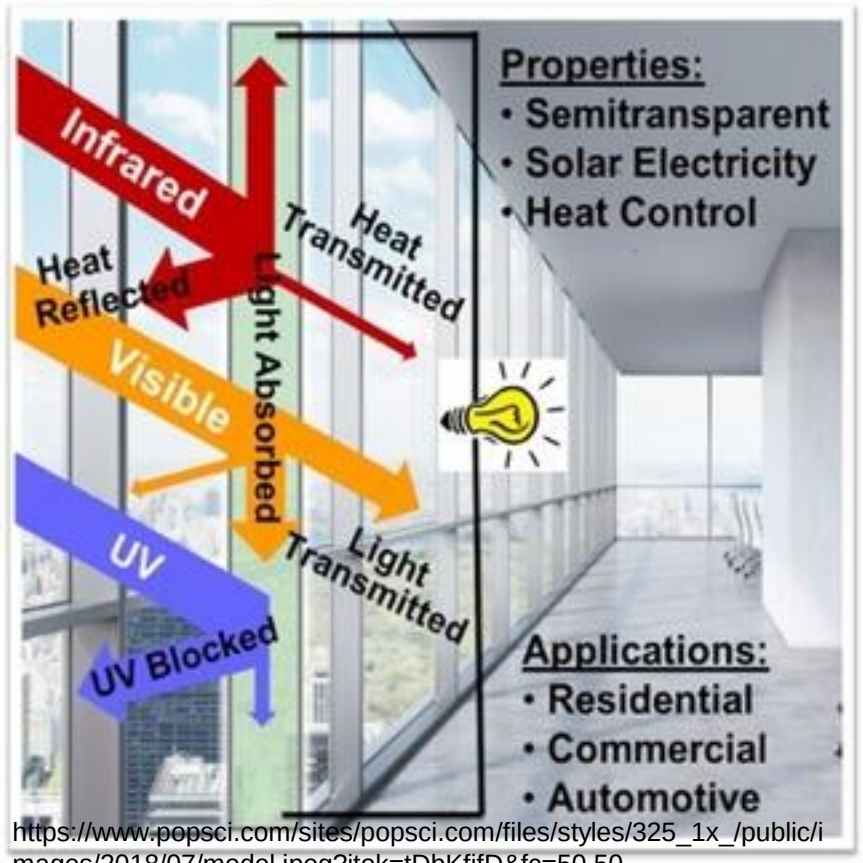


REN21 RENEWABLES 2018 GLOBAL STATUS REPORT

http://www.ren21.net/status-of-renewables/global-status-report/

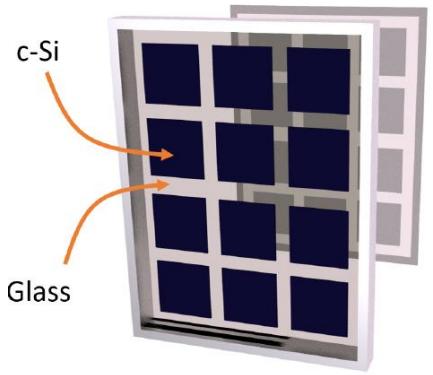
TAL TECH

Make buildings from energy users to energy producers- **solar windows**

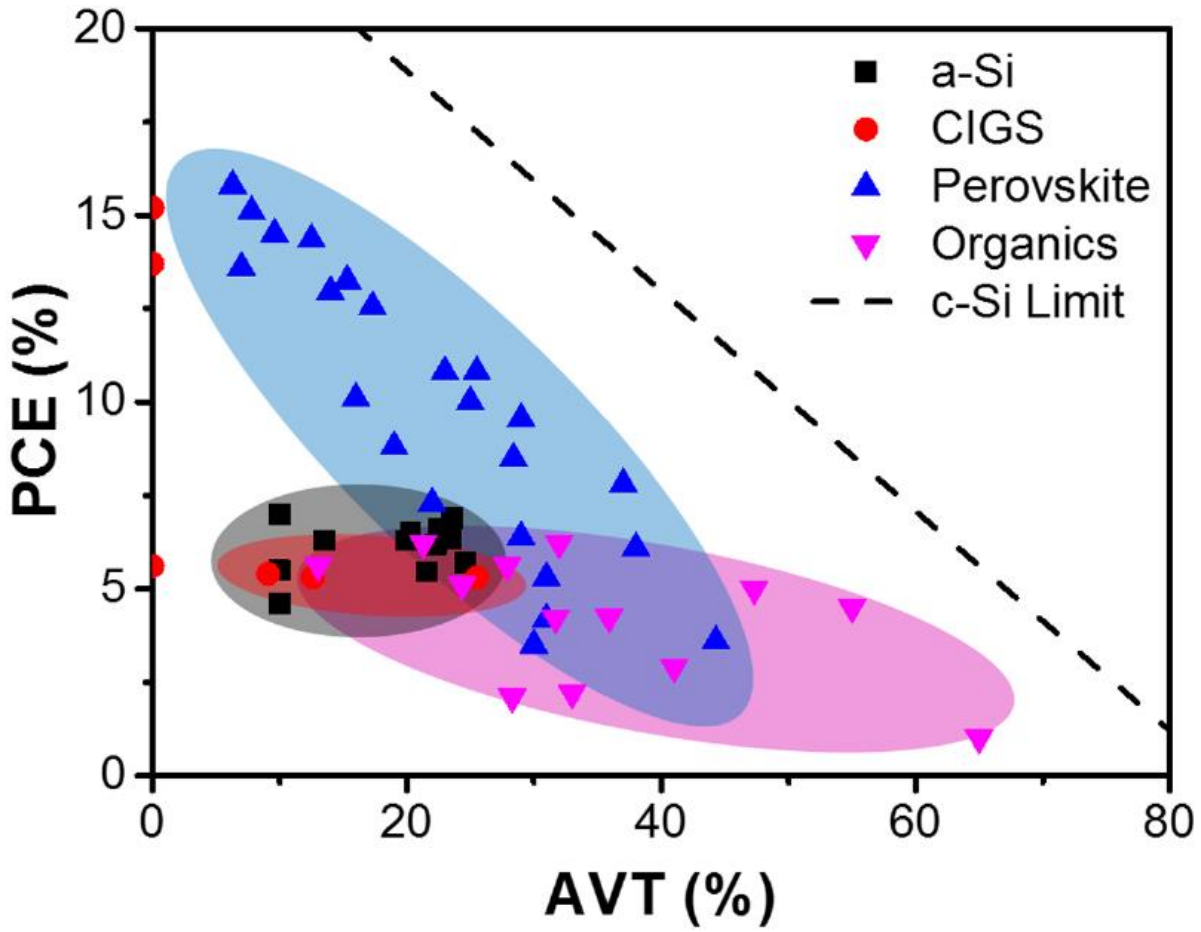


https://www.popsci.com/sites/popsci.com/files/styles/325_1x_/public/images/2018/07/model.jpeg?itok=tDbKfifD&fc=50,50

Semi-transparent solar cells



semi-opaque

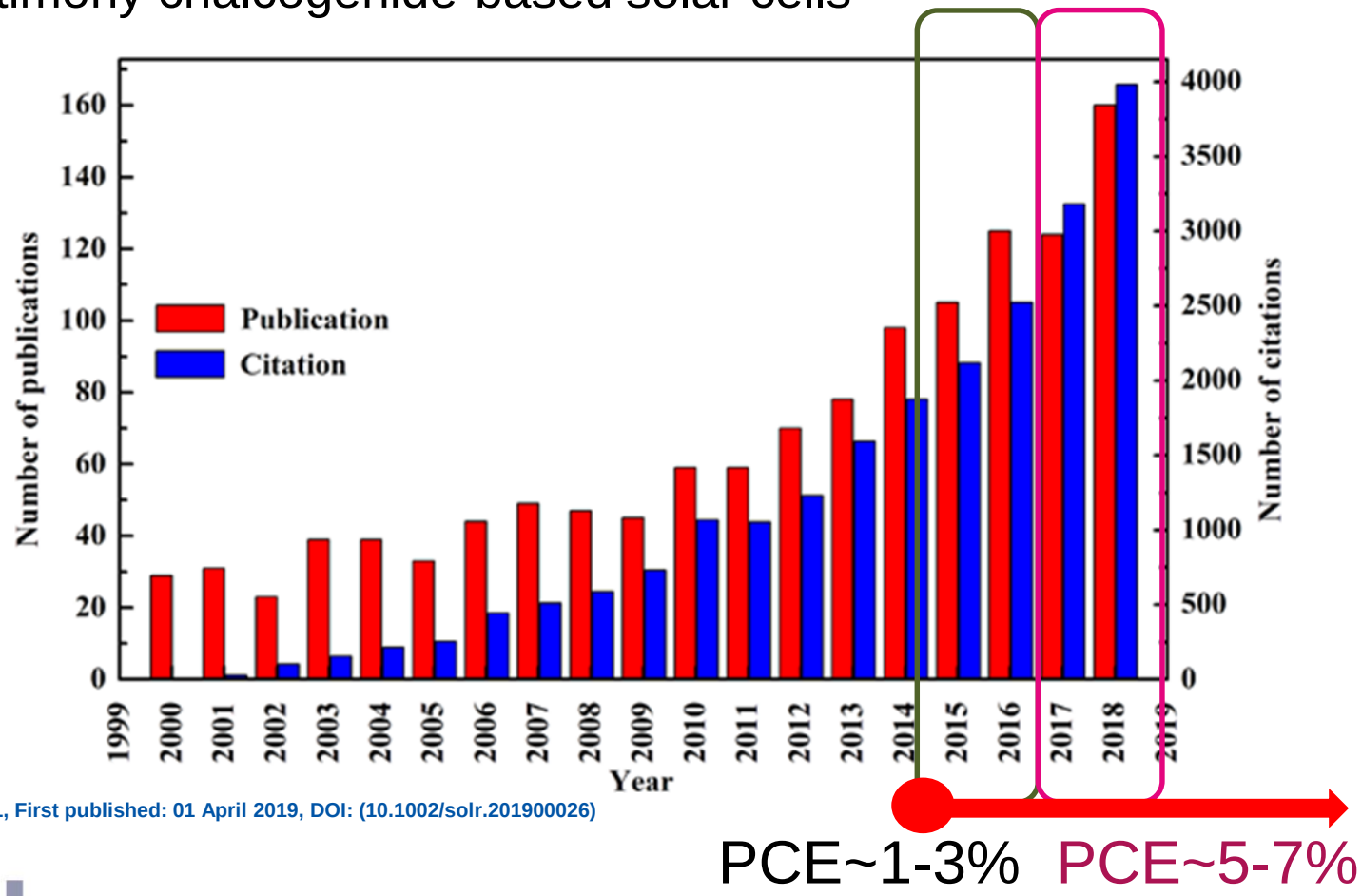


Semi-transparent

J.Phys.D:Appl.Phys.50 (2017) 093001

Antimony chalcogenides–booming absorber for solar cells

Antimony chalcogenide-based solar cells



Solar RRL, First published: 01 April 2019, DOI: (10.1002/solr.201900026)

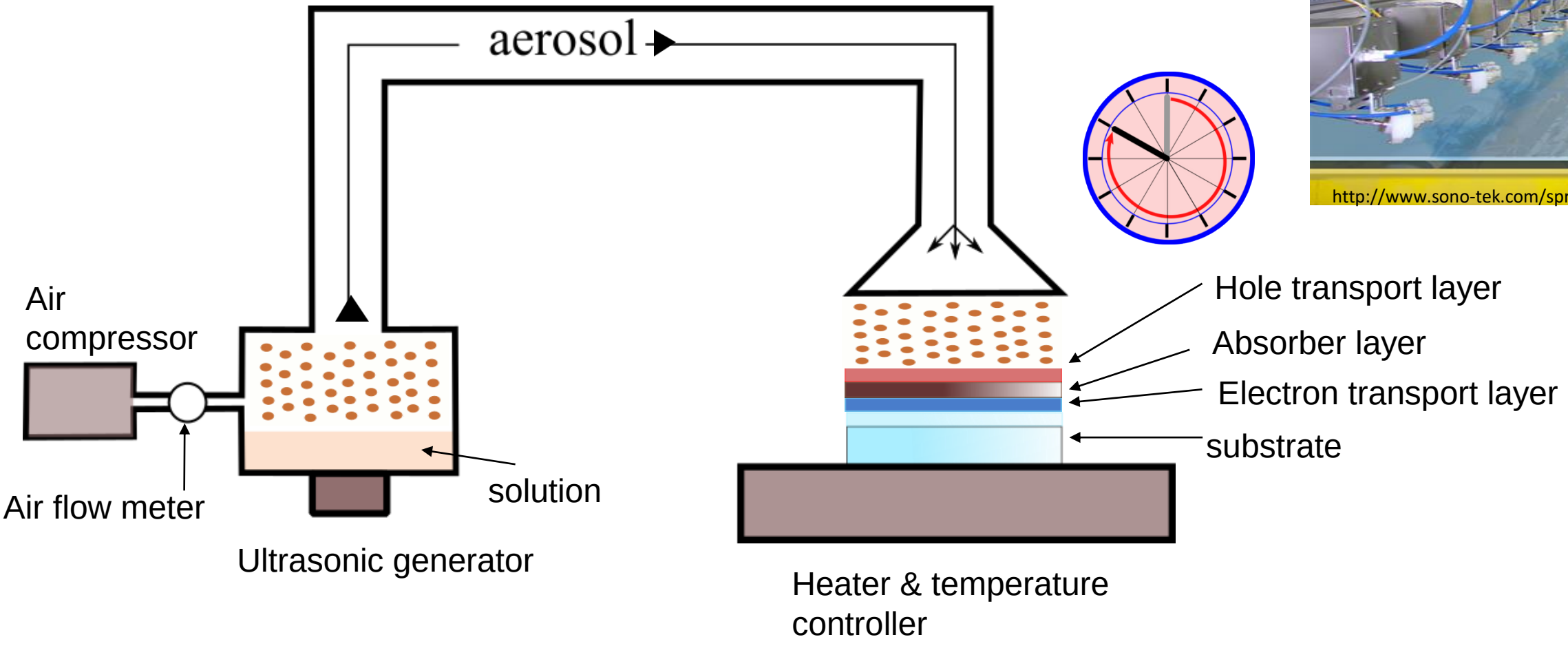
Sb_2S_3, Sb_2Se_3, $Sb_2(S,Se)_3$

Sb_2S_3

- S, Sb abundant in nature
- α ~ 1.8*10^5 at 450 nm
- E_g ~1.7 eV

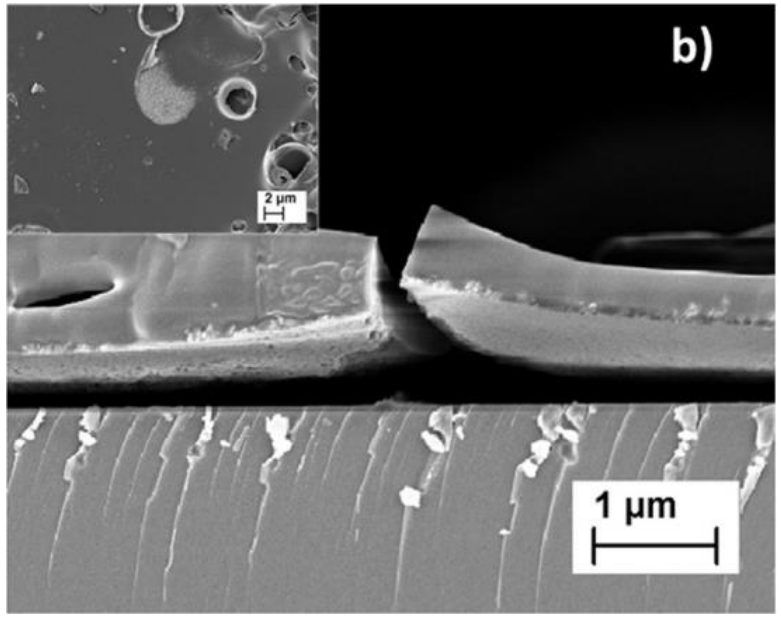
TAL TECH

Experimental



Sb_2S_3 by chemical spray (2015-2016)

T_{Dep} **230°C**

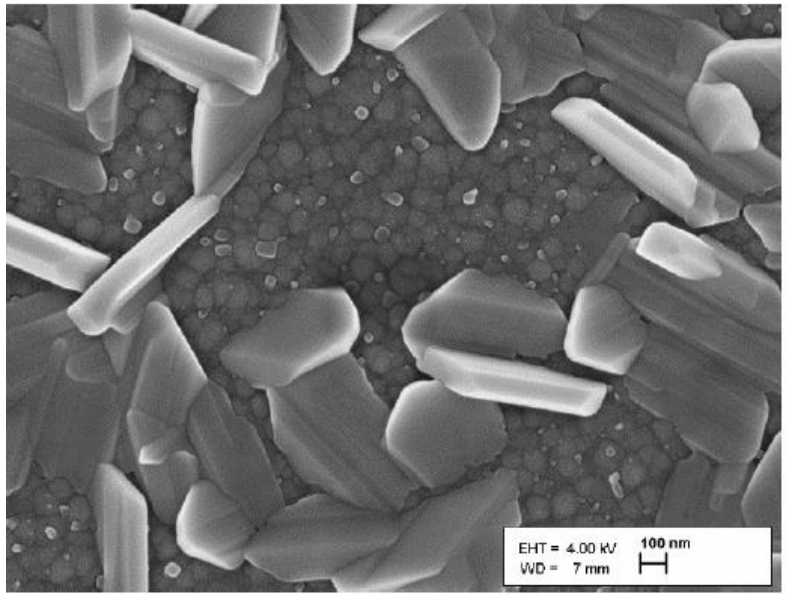


Aqueous solution + tartaric acid

Peeling inhomogeneous Sb_2S_3 layers, E_g 1.7 eV.

Kriisa *et al.*, *Mater. Sci. Semicond. Process.*, 2015

T_{Dep} **250°C**



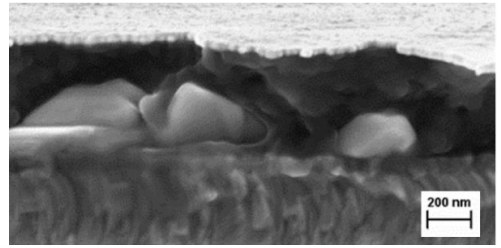
Non-aqueous solution

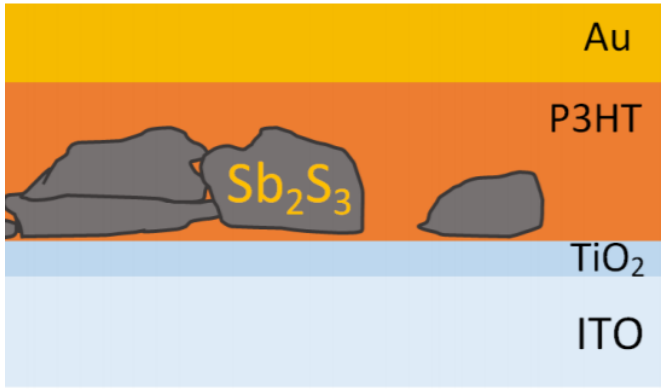
$(SC(NH_2)_2\,SbCl_3)$

Stoichiometric Cl-free Sb_2S_3 layers,

E_g 1.6 eV.

Incomplete substrate coverage.



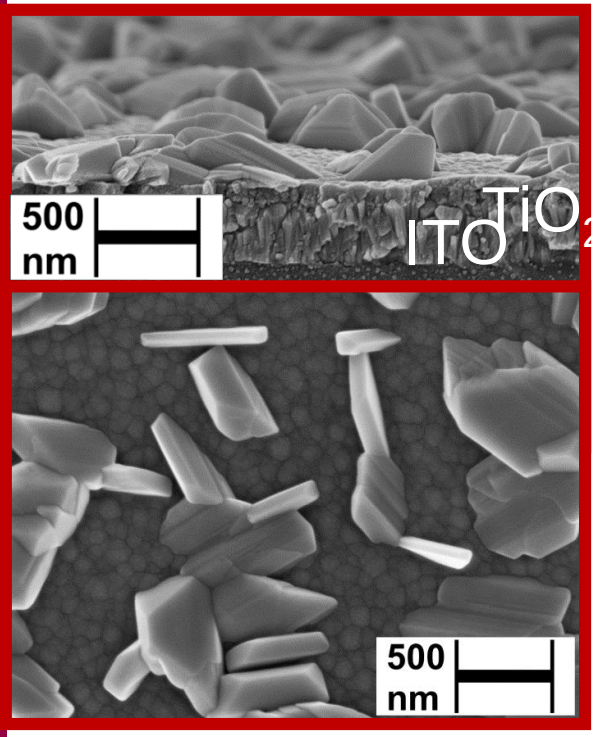


PCE=1.9%

Kärber et. al. Beilstein J. Nanotechnol. **2016,** *7,* 1662–1673.

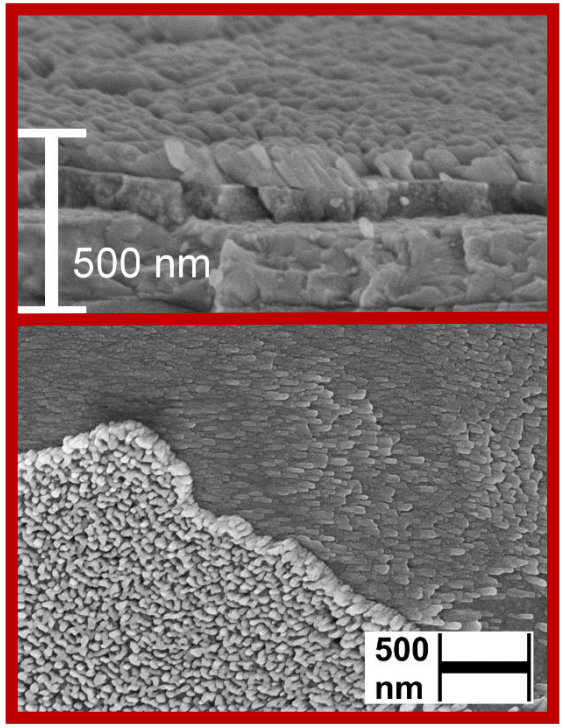
Morphology

Sb:S **1:6**, As-dep. **250°C**



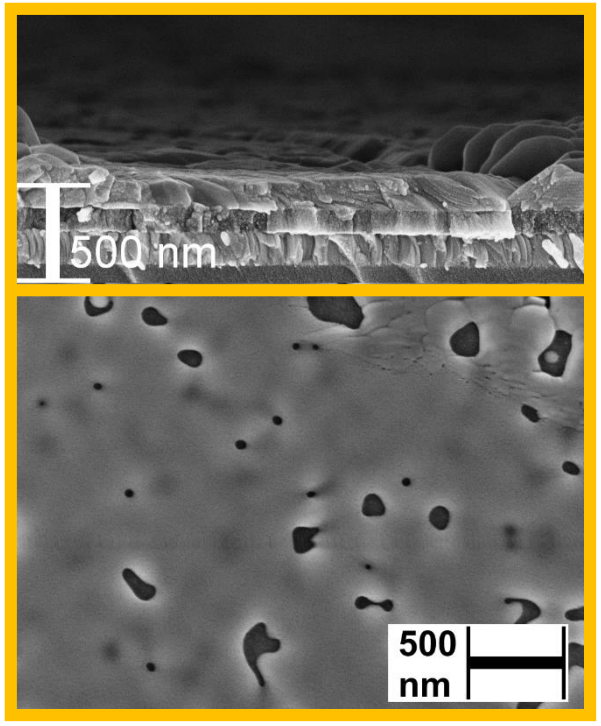
Separate **grains**

Sb:S **1:3**, As-dep. **220°C**



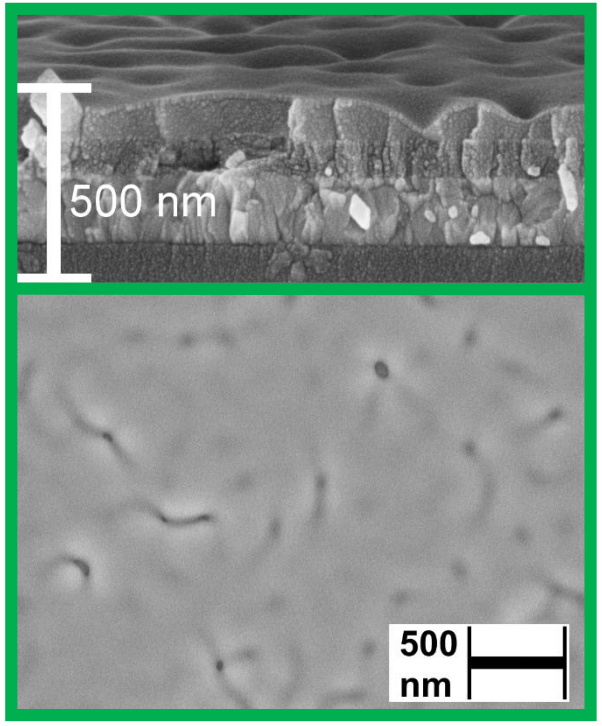
Well-defined **grains**

Sb:S **1:6**, As-dep. **210°C**



Coalesced islands & **grains**
Incomplete coverage

Sb:S **1:3**, As-dep. **210°C**



Coalesced islands,
near-complete coverage

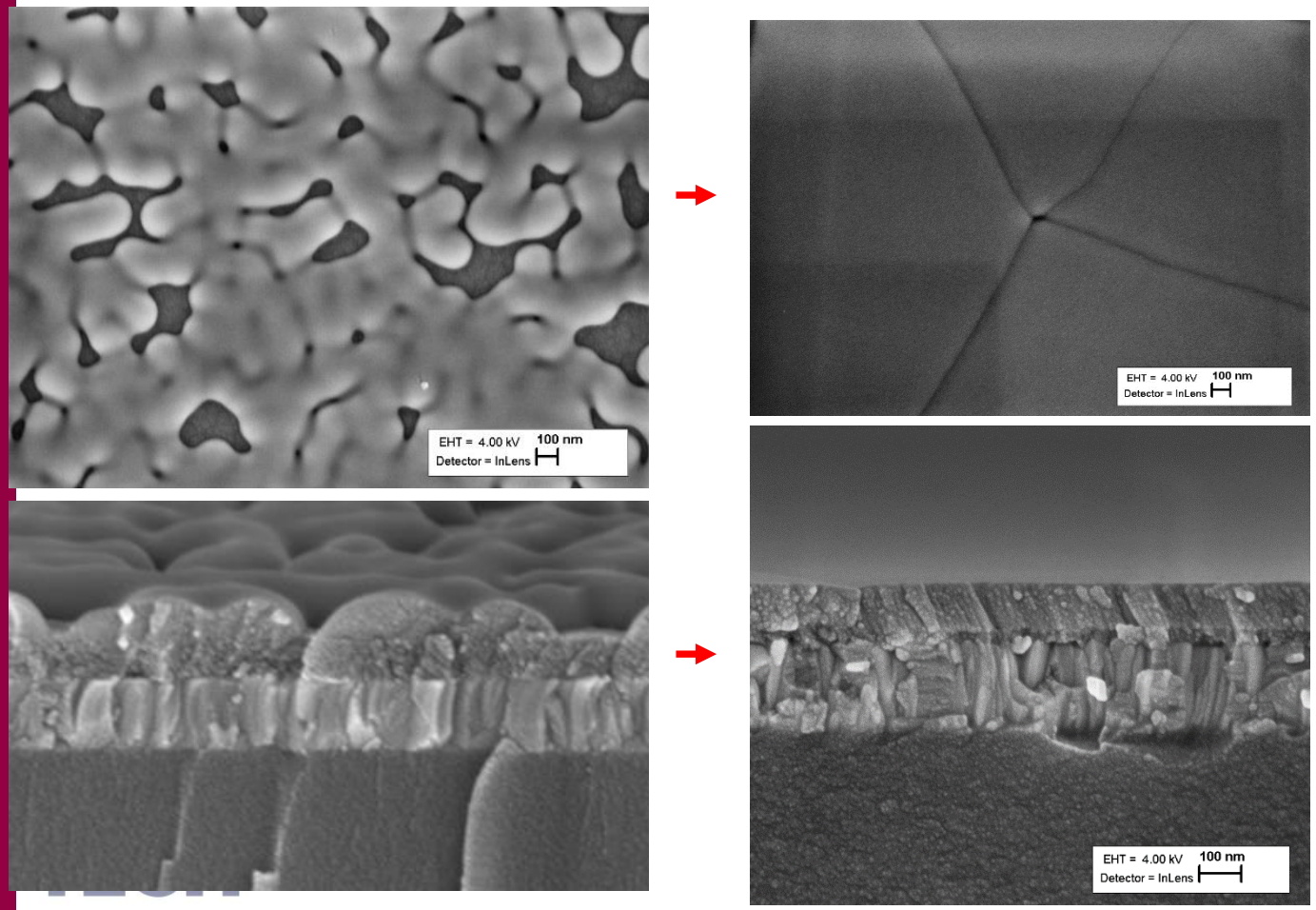
J.S.Eensalu, Beilstein Journal of nanotechnology, 10, 2019, 198.

Sb_2S_3/TiO_2 films spray deposited at 210°C and annealed

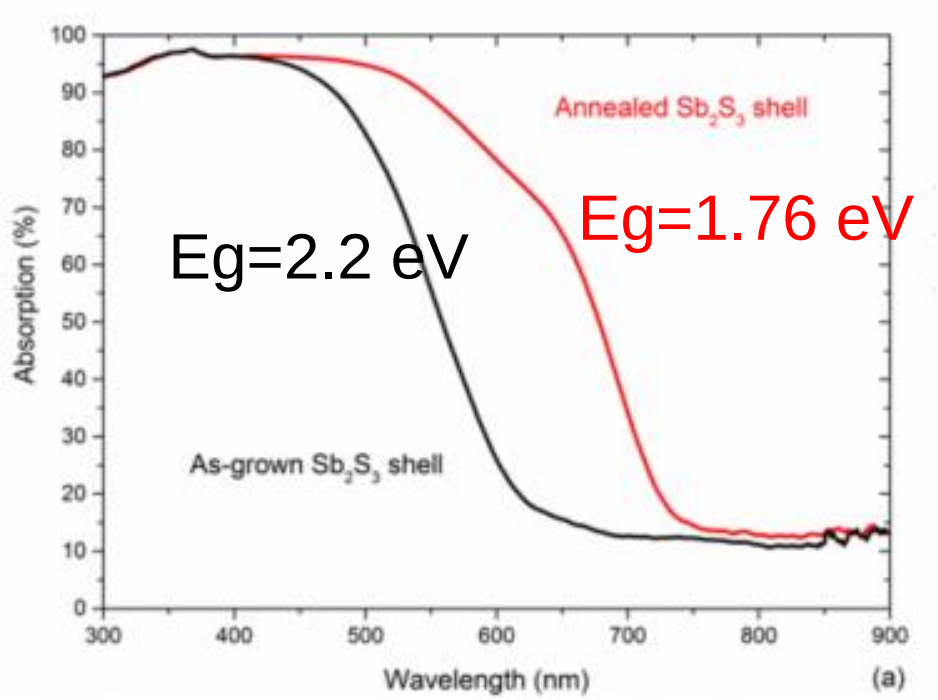
Sb:S **1:3**, As-dep. **210°C**

5 min, 170°C in vacuum or flowing N_2

Amorphous → Crystalline



UV-visible absorptance

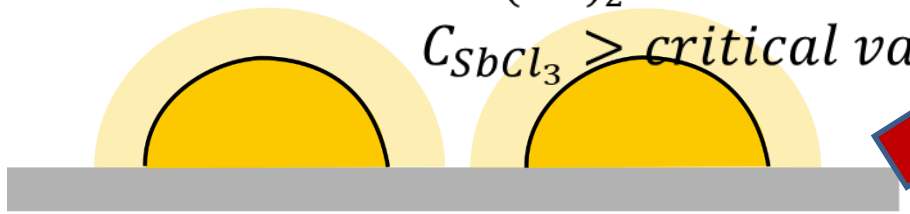


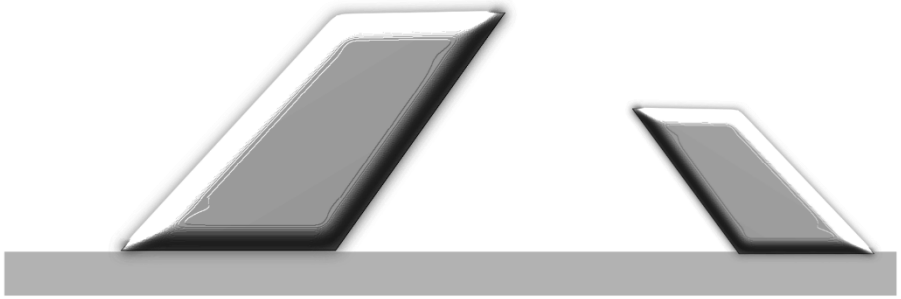
J.S.Eensalu, Beilstein Journal of nanotechnology, 10, 2019, 198.

Possible growth mechanism of Sb_2S_3 containing layers

J.S.Eensalu, Beilstein Journal of nanotechnology, 10, 2019, 198.

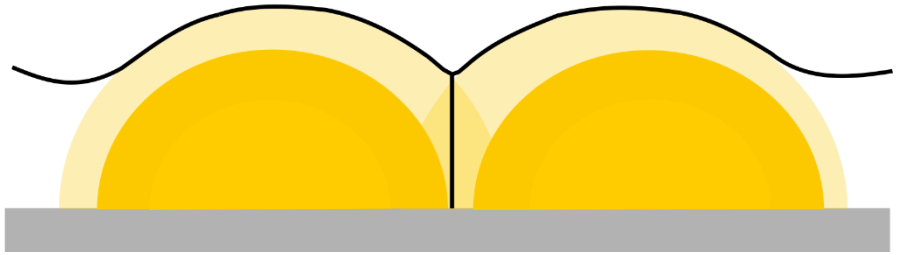
$$T_{Deposition} > critical\ value$$
$$t_{Deposition} > critical\ value$$
$$C_{SC(NH)_2} > critical\ value$$
$$C_{SbCl_3} > critical\ value$$





Uncontrollable **separate** grain formation

Volmer-Weber growth – formation of separate islands followed by coalescence into grains



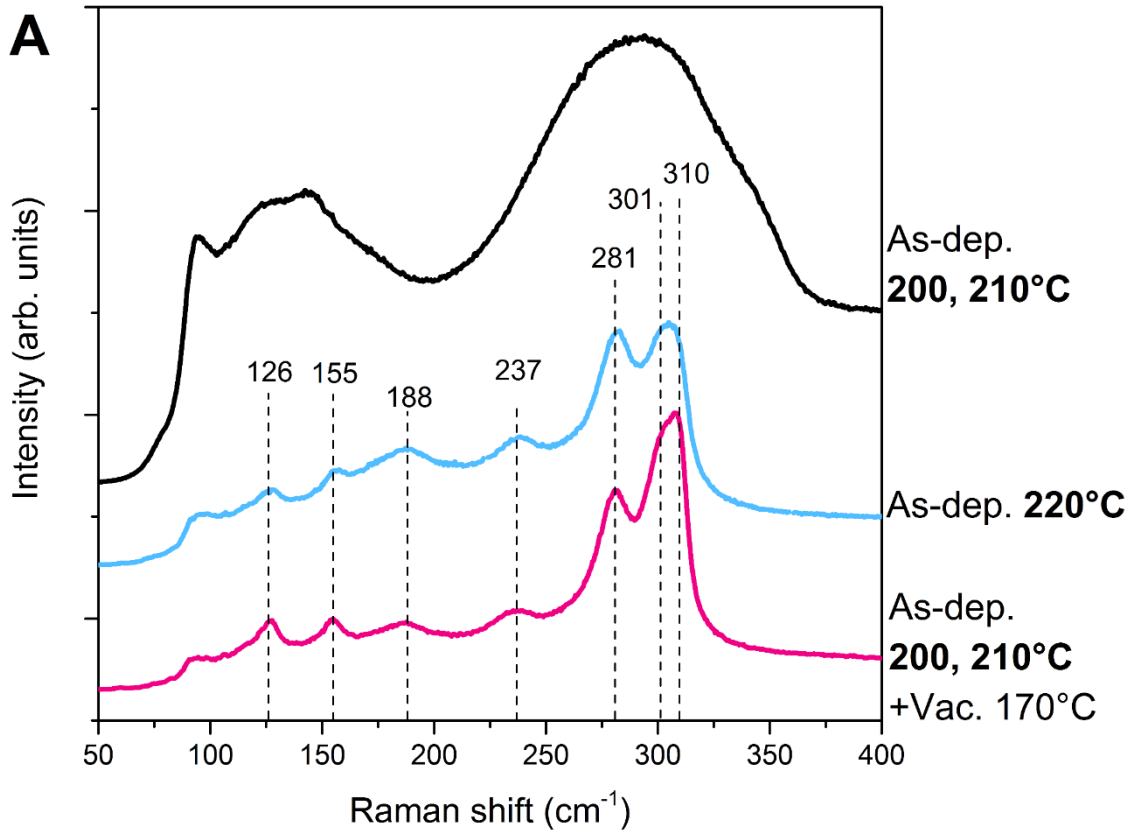
Controllable grain growth
Complete coverage at sufficient thickness

TAL TECH

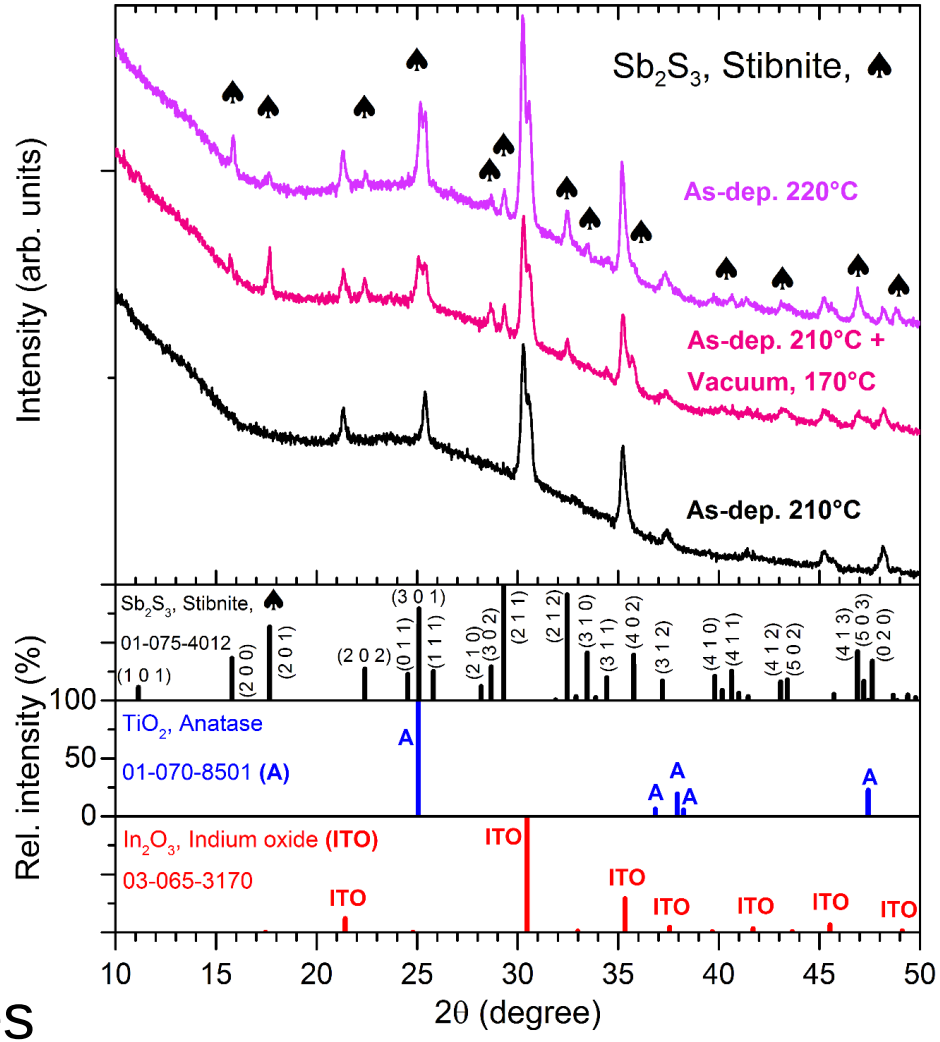
Structural studies

sample - glass/ITO/TiO_2/Sb_2S_3

Sb:S **1:3** in sol.



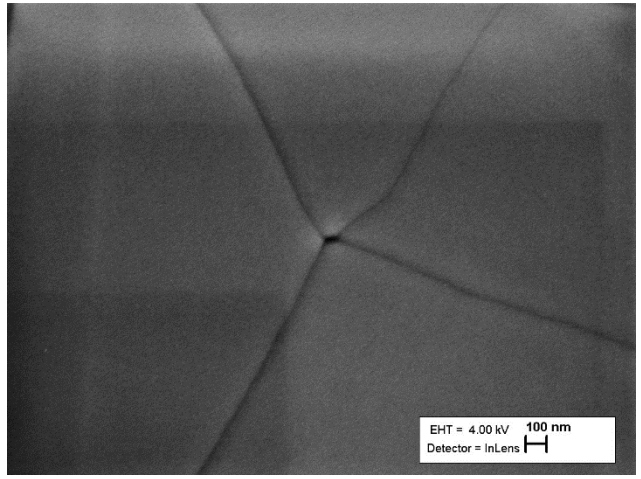
Sb:S **1:3** in solution

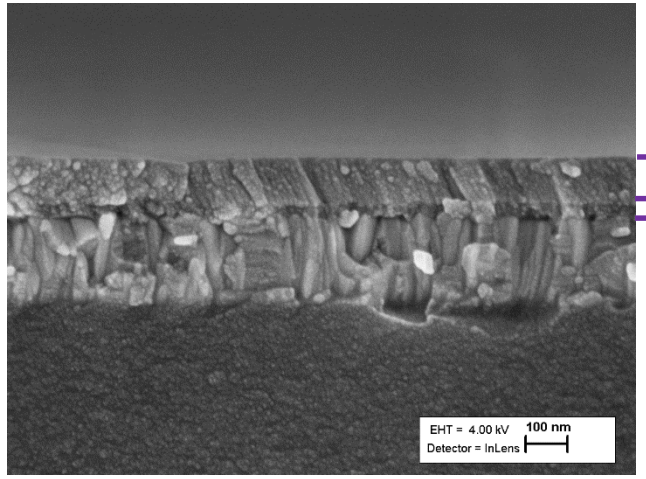


No Sb_2O_3 detected in any samples

J.S.Eensalu, Beilstein Journal of nanotechnology, 10, 2019, 198.

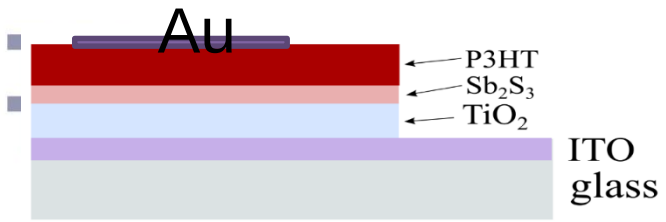
Hybrid Sb_2S_3 thin film solar cell efficiencies up to 5.5 %

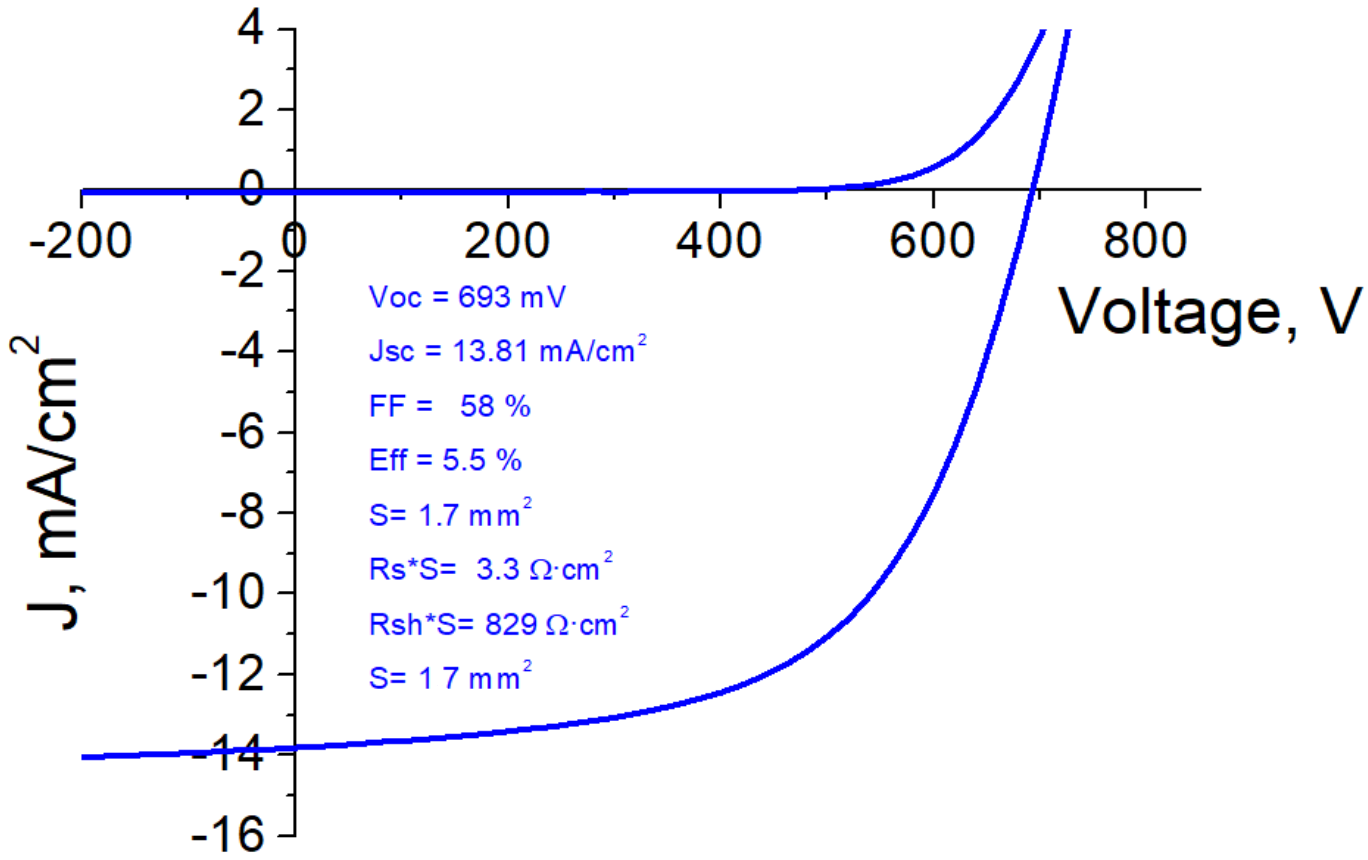




90 nm Sb_2S_3

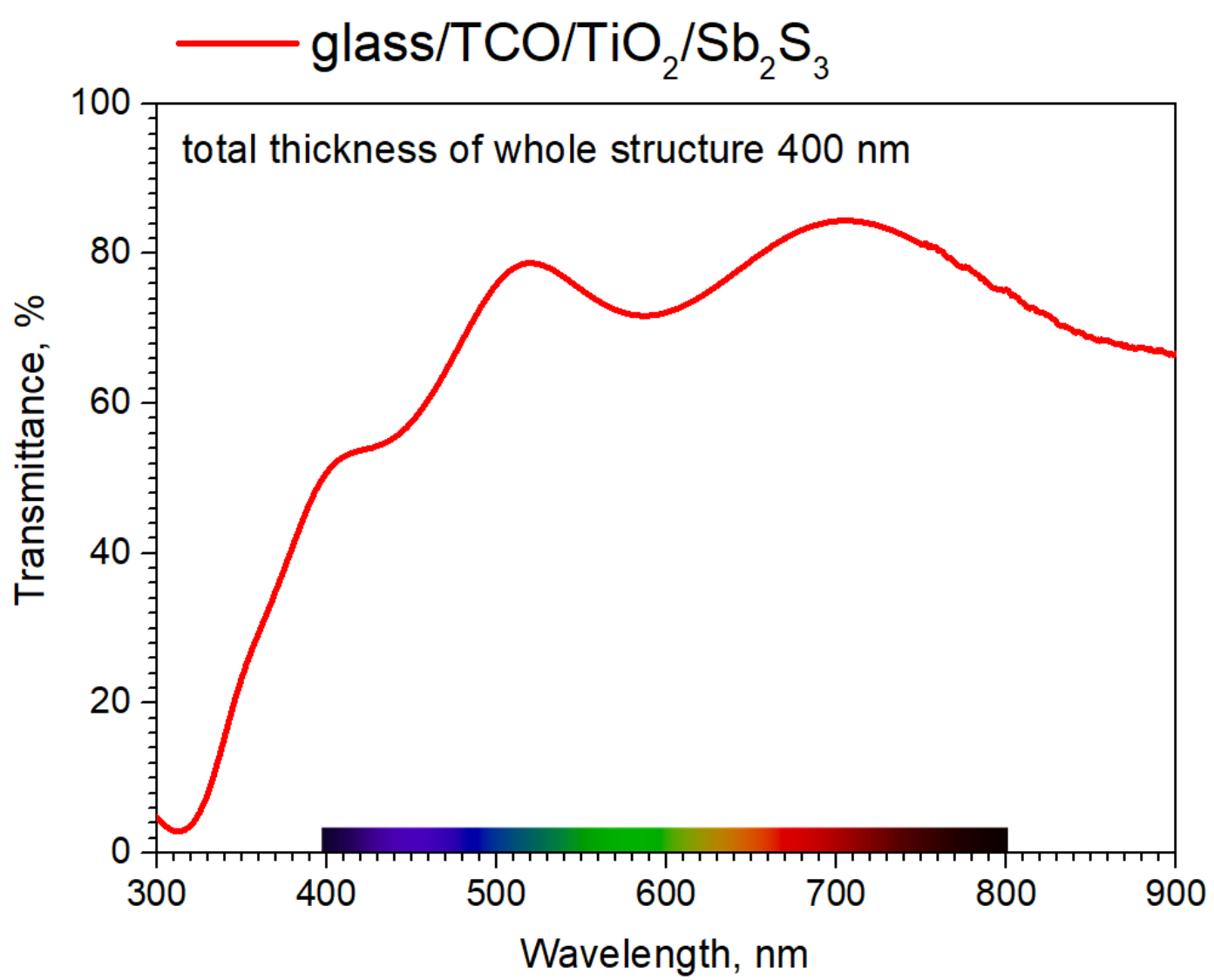
30 nm TiO_2

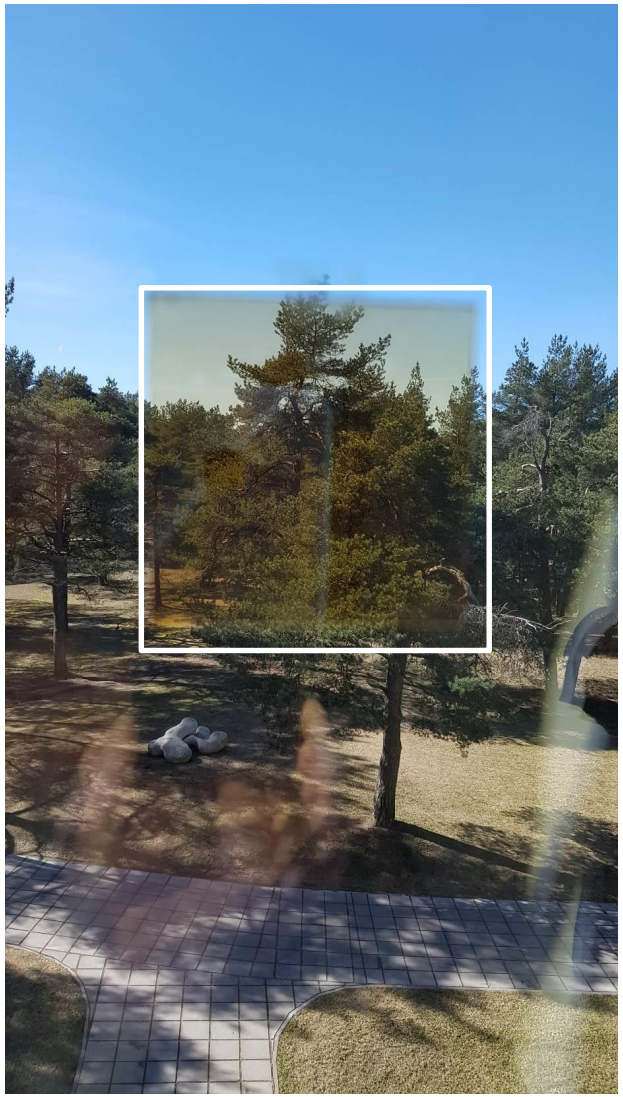




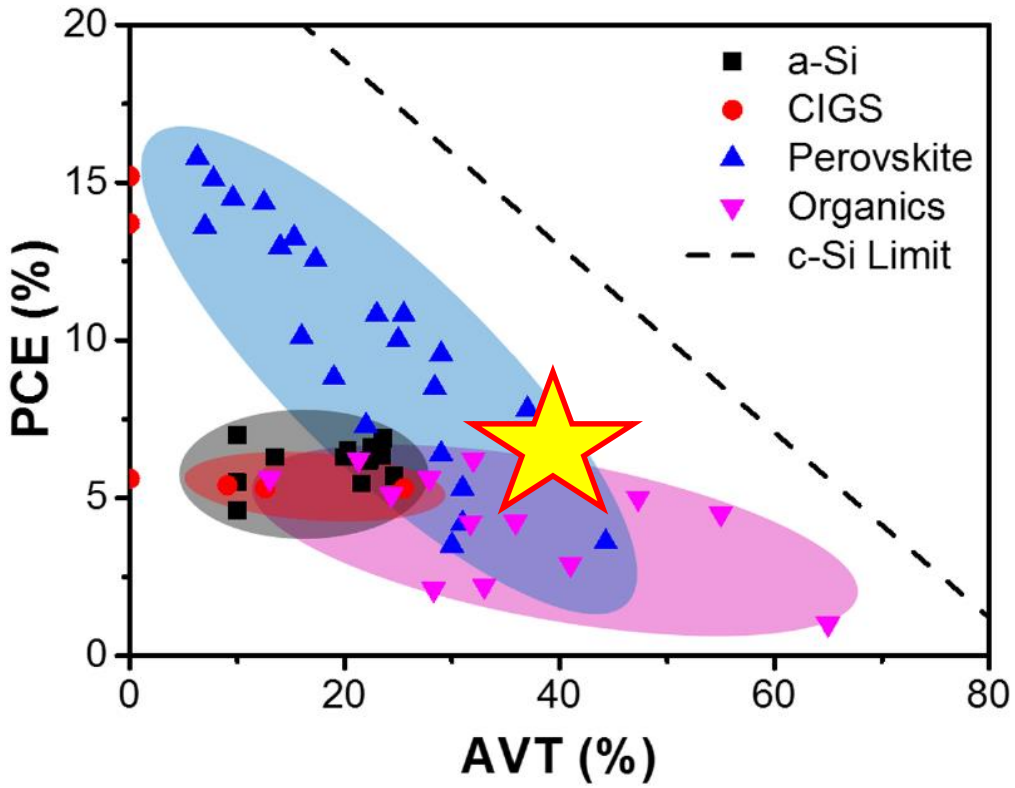
$TiO_2/Sb_2S_3/P3HT/Au$

Semi-transparent Sb_2S_3 thin film solar cell efficiencies

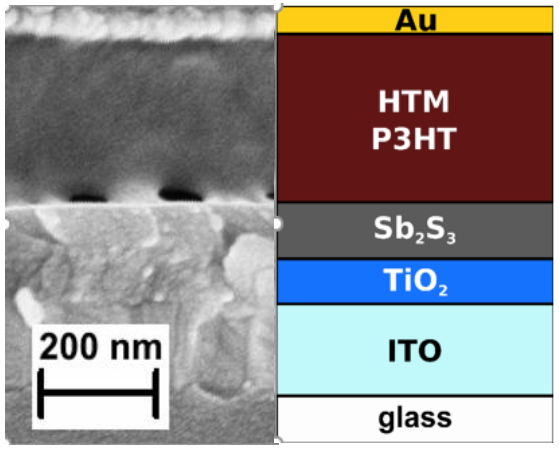




Summary-Sb_2S_3 based semi-transparent solar cells



AVT- avarage visible transimittance



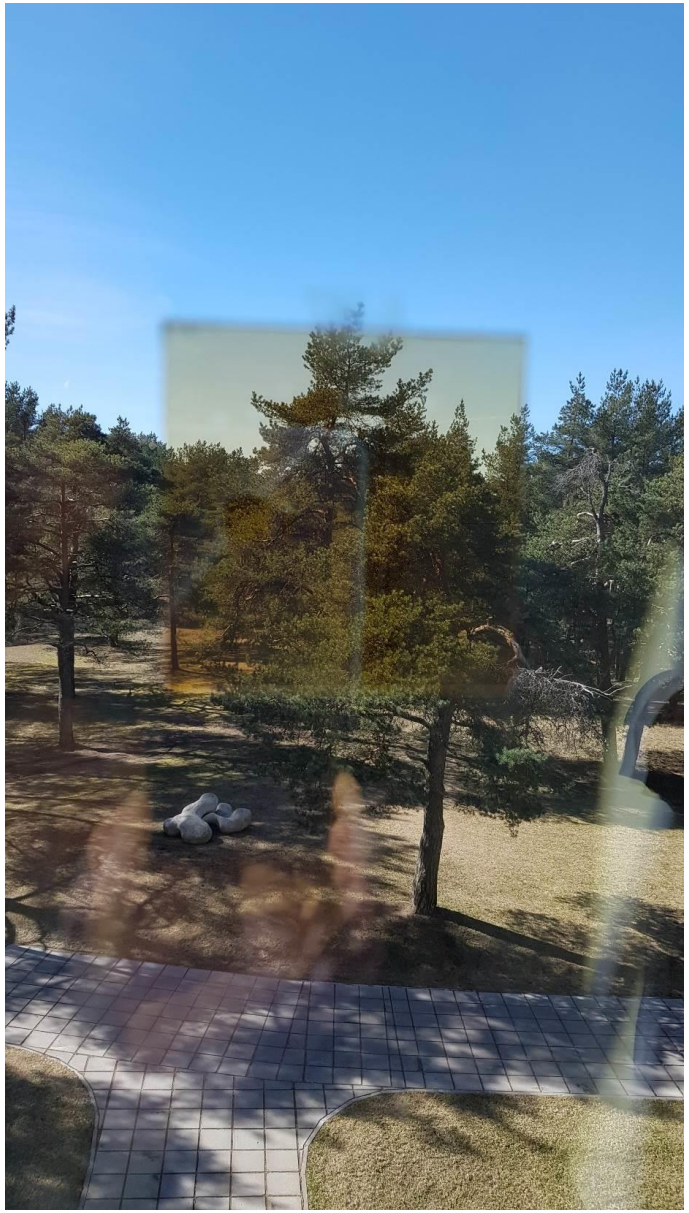
1 kg „Sb“ ca 5000 m^2

Leightweight: <10 g/m^2

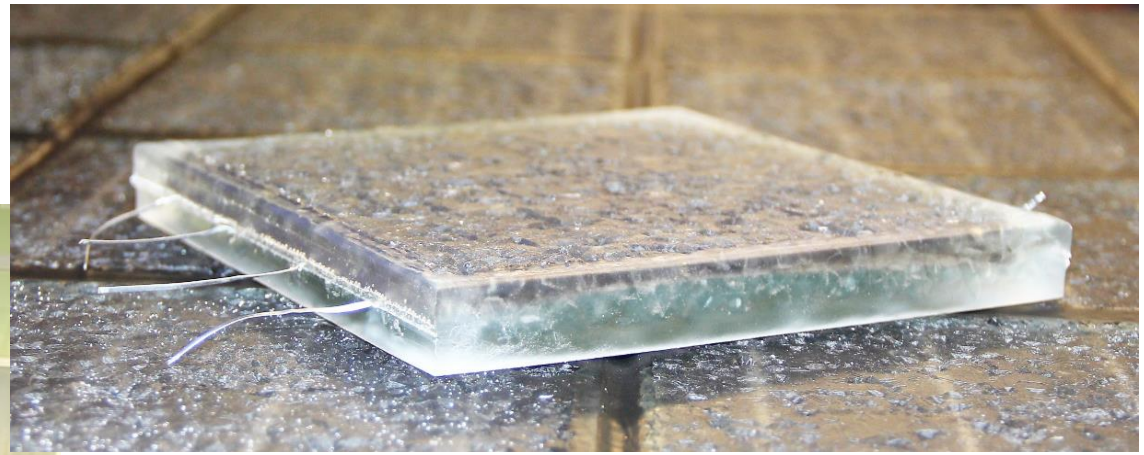
Fabrication time: ca 1 h

PCE=5.5%

PCE= 10%



Nutikas teekatend



2017-Maanteameti projekt „Nordic e-pavement“

2019 Tallinna Tehnikaülikooli arendusprojekt „Tark teekatend“

2018 Start-up e-Pavement OÜ

ACKNOWLEDGEMENTS

IUT-19-4 „Thin films and nanomaterials by chemical methods for next-generation PV“

Teaduse tippkeskus TK141 „Advanced materials and high-technology devices for sustainable energetics, sensorics and nanoelectronics“

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