Optimisation of $BaTiO_3$ thin films prepared by magnetron sputtering for sensor and solar cell use

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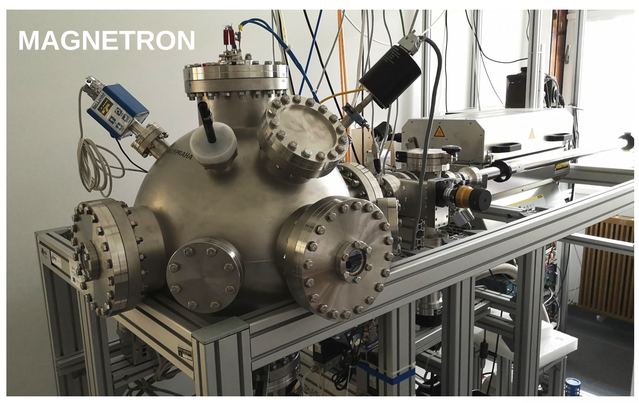
BACKGROUND & MOTIVATION

Perovskites are mineral materials which contain titanium, oxygen and at least one additional metal such as: Sr, Ba, Ca. Because of their good ferroelectric and piezoelectric properties, perovskites have found their use in electronics (capacitors, microphones, devices for digital data storage). Barium titanate ($BaTiO_3$) is a ceramic perovskite oxide that besides having ferroelectric has good optical properties. That alone makes it an interesting material for photovoltaics.

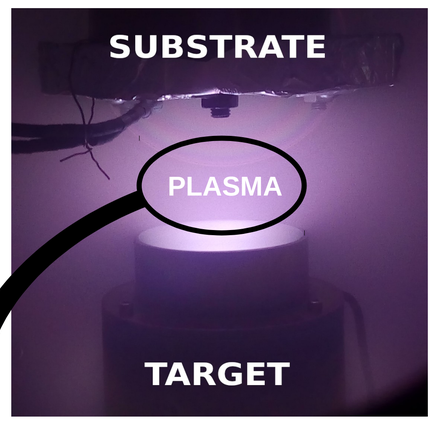
Nanocrystalline $BaTiO_3$ thin films were prepared by RF magnetron sputtering followed by annealing at different temperatures. Deposition parameters (discharge power, working gass pressure and composition) were varied to obtain samples with different optical properties.

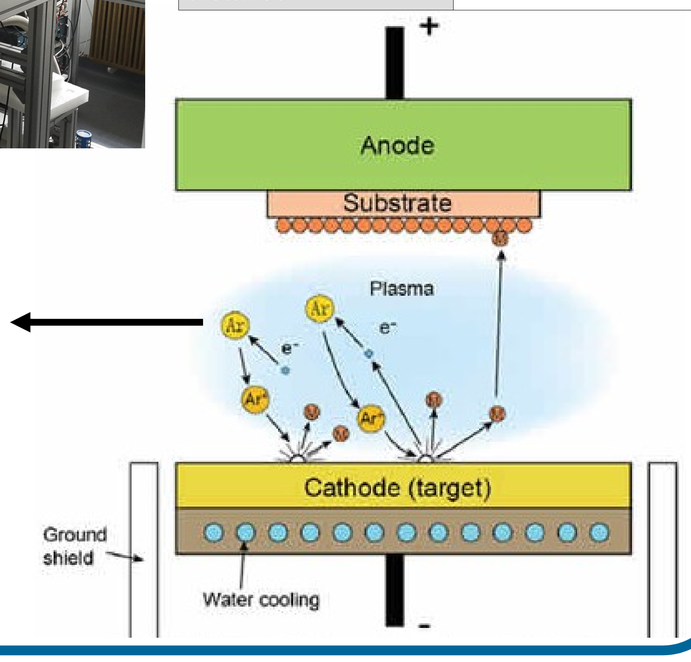
SAMPLE PREPARATION

Quarz glass or Si wafer → RF magnetron sputtering Target: $BaTiO_3$ Working gas: Ar or $Ar+O_2$ → amorphous $BaTiO_3$ thin film → Post-sputter annealing 500-1000°C → nanocrystalline $BaTiO_3$ thin films



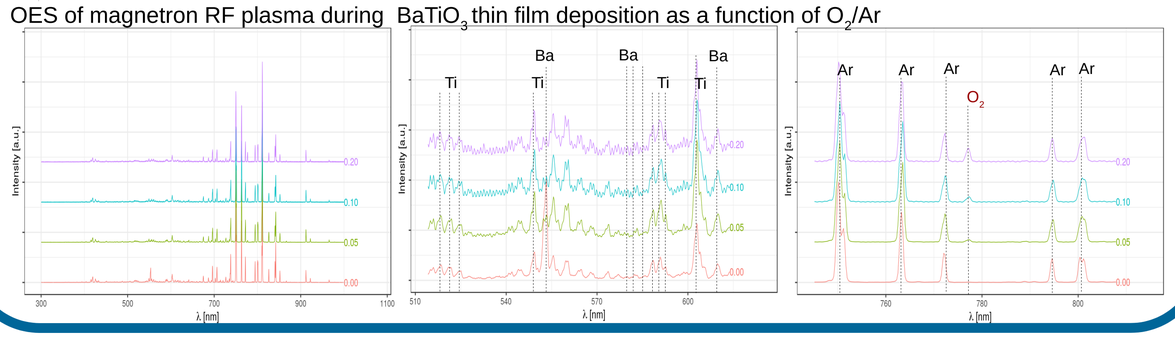
base pressure	$1 \cdot 10^{-7}$ mbar
working gas pressure	$5 \cdot 10^{-3}$ - $1 \cdot 10^{-2}$ mbar
power	40 - 100 W
target diameter	2"
target to substrate distance	100 mm



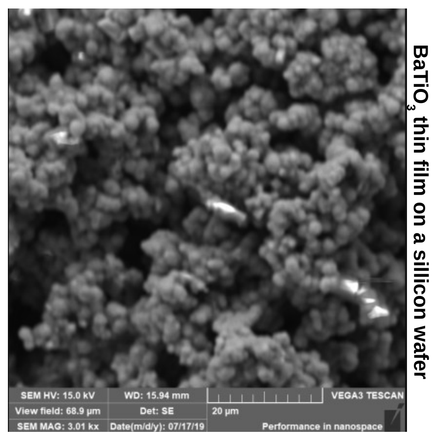


OPTICAL EMISSION SPECTROSCOPY

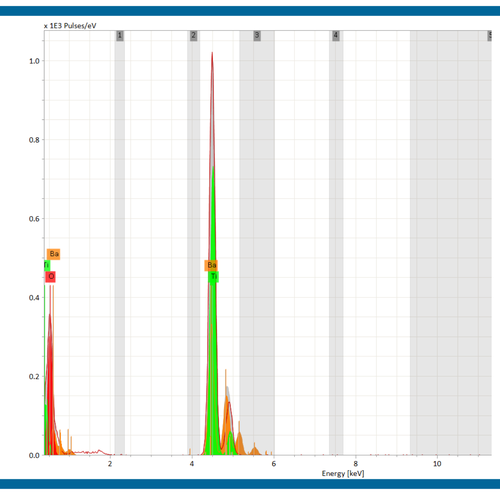
OES of magnetron RF plasma during $BaTiO_3$ thin film deposition as a function of O_2/Ar



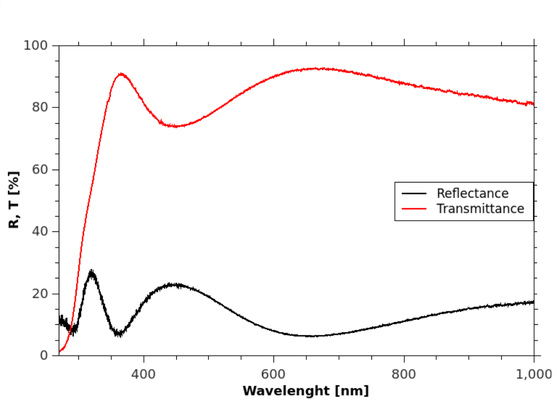
SEM & EDS



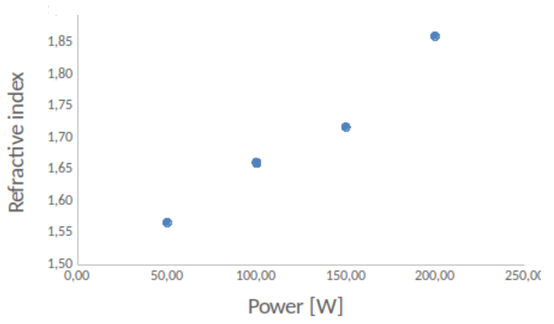
$BaTiO_3$ thin film on a sillicon wafer



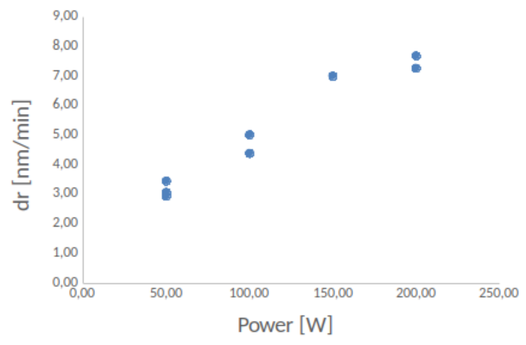
OPTICAL PROPERTIES OF $BaTiO_3$ THIN FILMS

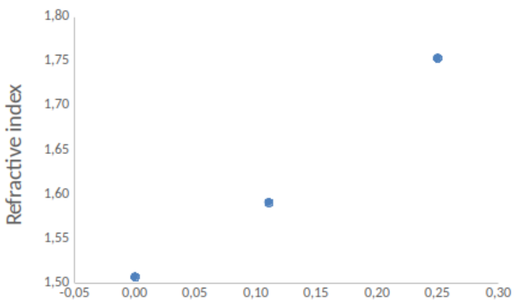


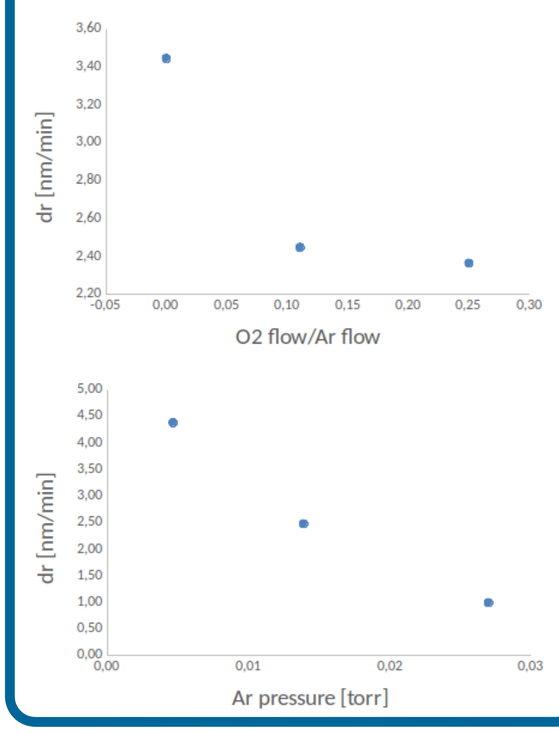
REFRACTIVE INDEX

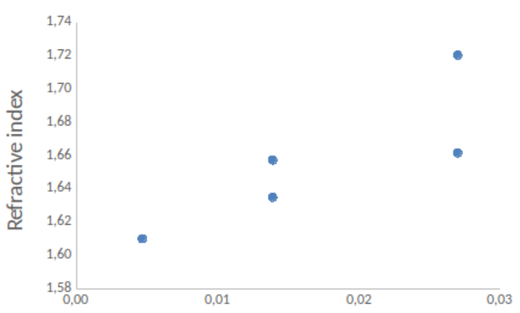


DEPOSITION RATE

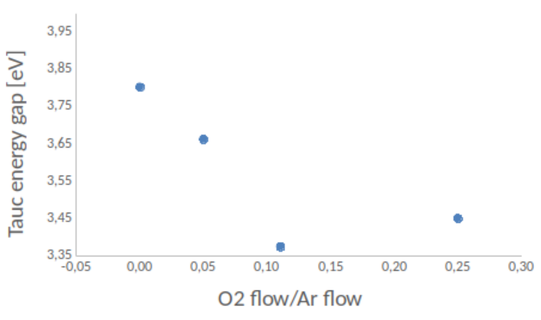






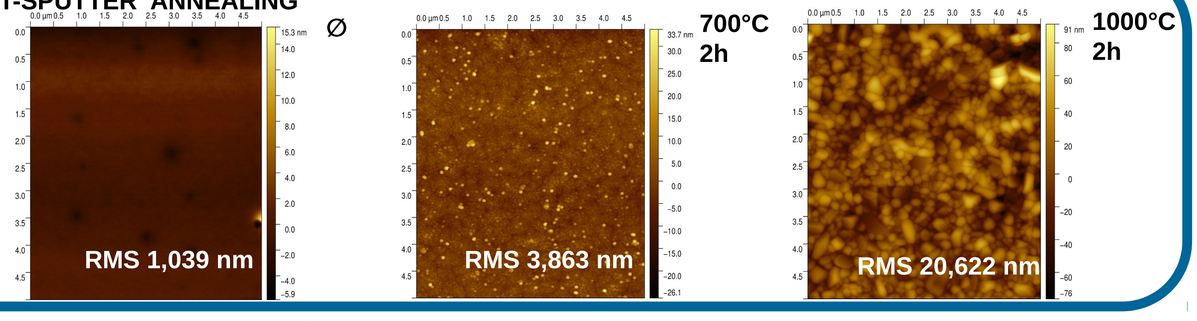


TAUC ENERGY GAP



ATOMIC FORCE MICROSCOPY

POST-SPUTTER ANNEALING



SUMMARY

- $BaTiO_3$ thin films (100-500 nm thick) were prepared by RF magnetron sputtering and post-deposition annealing at different temperatures (700-1000°C)
- Annealed $BaTiO_3$ samples had a nanocrystalline structure and increased surface roughness (RMS)
- By varying sputtering conditions (discharge power, working gass pressure and composition) we were able to effect the optical properties (Tauc energy gap and refractive index)

ACKNOWLEDGMENT

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HrZZ Hrvatska zaklada za znanost